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METAL TURNING MADE EASY

With 177 Illustrations

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EDITOR'S PREFACE

THIS is a companion volume to "The Simple Lathe and Its Accessories," and its object, as defined in its very first paragraph, is to explain in detail the various lathe operations of turning, boring, screw cutting, etc., etc. It will be found to be a very complete and certainly an up-to-date treatise on modern lathe-work practice of the amateur's and small professional's workshop. Of one thing the reader can be certain: the methods advanced are those adopted by practical men of long workshop experience. The greater part of this volume is from the pen of Mr. Fred Horner.

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METAL TURNING MADE EASY

CHAPTER I

Turning Between Centres

Introductory.—It is the purpose of this handbook to explain in detail the various operations of turning, boring, screw-cutting, etc., in the lathe, and to deal with all the subsidiary processes in connection with them. It is presumed that the reader has already studied the companion handbook, "The Simple Lathe and Its Accessories" (in the same style and at the same price), which describes the various types of lathes, modern small lathes, centres, catch pins, catch plates, carriers, chucks, faceplates, mandrels, steadies, hand-rests and slide-rests, lathe attachments, methods of driving and testing the lathe, and no attempt will be made in this volume to deal with matters coming within the scope of those headings.

For the benefit of readers who may not have read the companion volume, however, the diagram of a lathe showing its chief components is here reproduced (*see* Fig. 1). In order that subsequent references to these terms may easily be followed, it may here be mentioned that the *change wheels* are used for self-acting feed and screw-cutting, the *gap* is to allow of a larger diameter of work on faceplates than is permitted between centres, the *slide-rest* is used for guiding the tool, the *catch pin* is for driving the work, and the *back-gear* is to permit of a slower revolution of the work than may be obtained from the cone pulley or countershaft. The other terms in the illustration are sufficiently obvious to need no special mention.

Choice of Tools.—Presuming the lathe to be in good condition, and the chucking performed correctly, there remains the consideration of the use of the tools. The difficulties of getting under scale, of negotiating hard spots, and of obtaining the right size and the required quality of finish, call for a careful choice of tools, and also discretion in their usage. These problems are less easy of solution when the allowances for turning are fine than when there is plenty of metal to be removed. In the first-named instance one has to be extremely careful from the commencement, so as to centre or to chuck the piece that it may clean up, and this caution must be maintained right through the processes, taking careful cuts, and guarding against risks of digging in or too deep a cut. If there is hard scale on the bar, casting, or forging, this fact adds to the awkwardness of cleaning up, because the tool-point scrapes on the scale at part of the revolution of the work. Such an occurrence has two injurious results: one being that the tool is pushed away or the work springs, the other that the keen edge of the tool is rapidly dulled or chipped.

Methods of Driving Work.—The precise method

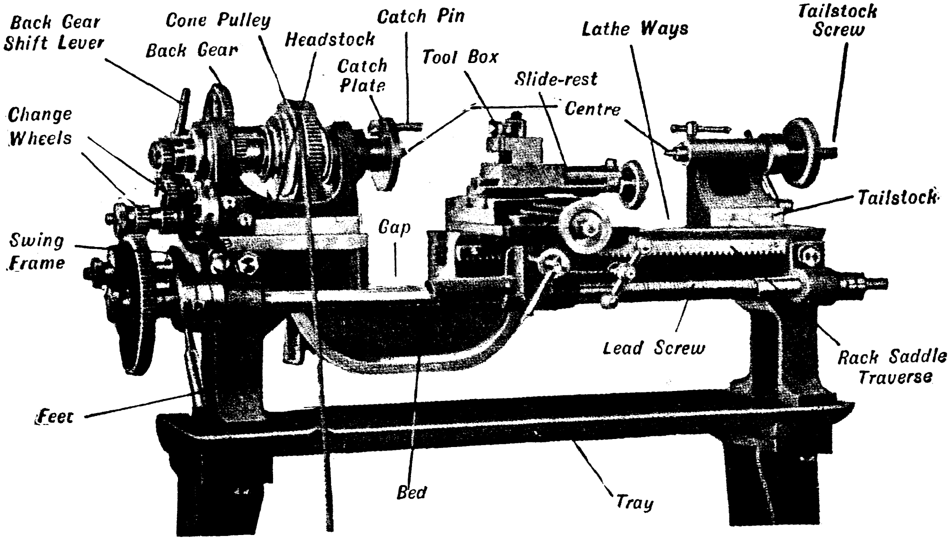


Fig. 1.—Illustration of Lathe with Main Components Named

of holding for producing rotation of the work is not always a hard and fast matter. There are sometimes two or three ways of accomplishing the same end, but generally one method offers an advantage over the others. For example, a bar can be held in the jaw chuck at the one end and run on the back centre, instead of using the headstock centre and a carrier. This is sometimes satisfactory where the retention of the centres is not necessary, but the better procedure is properly to centre both ends, and thus have accurate holes for future use. Jobs which can be carried without support from the back centre are also capable of more than one method of holding, such as being strapped on the faceplate, forced or gripped in the bell chuck, pushed into a wood chuck, driven by faceplate dogs on the edge, or with the regular jaws of an independent or a concentric chuck (refer to Chapter IV. of the companion handbook). More unusual devices are on certain occasions adopted, such as solder chucks or shellac chucks. Some objects present greater trouble because of the difficulty of gripping them with any of the ordinary chucks, and special fitments for holding have to be turned up to match some part. Eccentrics and other details that have to be thrown off centre for a portion of the turning also require special holding apparatus.

As mentioned earlier, the vital principle to be observed in all classes of chucking is that the position of the article shall remain unaltered. Thus, a shaft run between centres should not become compressed in the centre holes, or worn while revolving so as to interfere with the truth of the turning. Nor should a piece fastened to the faceplate or pinched in a chuck move or slip, or suffer distortion due to tightening the chuck. This last-specified point is rather a difficult one to avoid and also to trace, for with the desire to obtain a secure grip there is very often excessive pressure applied, and the work is distorted; when the hold is again loosened the turned shape will not be circular, but elliptical or oval, or even polygonal.

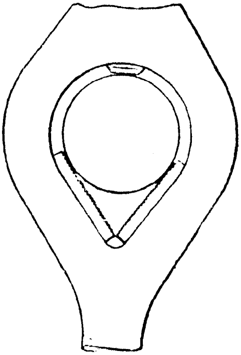


Fig. 2.—Using Pieces of File to Increase Grip of Carrier

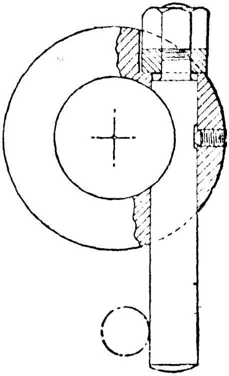


Fig. 3.—Special Carrier for Polished Work

A method which is adopted in some of these cases is to obtain a positive drive against the article with a pin or other device fixed on the chuck, in order that the work shall be revolved against the tool without having to rely on the pressure of the jaws. The well known practice of slightly releasing the hard grip of a chuck before taking the finishing cut must be followed with care or there will be risk of a displacement.

To provide an extra grip in a carrier for driving rough bar for heavy cuts, two pieces of broken file laid in as shown in Fig. 2 prove effective. The backs of the pieces may be ground a little smooth, so as to avoid damaging the carrier. In Fig. 3 a special carrier is shown for use on bright work, where a regular run of work of uniform size is being dealt with. A collar is bored out to fit the work, and a draw-bolt is fitted in, with a grab-screw to stop it from twisting when the collar is off the work. The tail of the bolt projects sufficiently to engage against the driving-pin.

Mounting Work between Centres.—The principle of centering already detailed is well illustrated in the case of bars revolving between centres. Failure to perform the centering in a thorough manner means that the axis of the bar will gradually alter during the turning process, and will continue to do so as long as there is a want of coincidence between the shape of the centre holes and of the centres. This variation will naturally be greater in soft than in hard material, and may result in irregularly shaped centre holes, should the work be rough and irregular outside, and the cutting pressures consequently jerky. For a lengthy shaft which needs a good length of turning the centre holes should be made with care, not only to preserve the alignment, but to avoid wear on the lathe centres. The matter is of great importance when a mandrel has been made for permanent use, and the best method in such an instance is to lap and polish the holes out very smoothly to correspond with the centre angles, after which no change can occur with ordinary usage. (*See* Chapter VI. of the companion handbook, where mandrels are fully discussed.)

Centering Bars.—A piece of bar should be straightened, and the ends squared before attempting to put in the countersinks. Any effort to straighten after the centering has been done will throw the recesses out of alignment, and the fit on the centres must consequently be imperfect. A similar occurrence arises if a bar warps after the skin tension has been removed by a roughing cut, the displacement then resulting in a bad fit, as indicated in an exaggerated manner by Fig. 4. As the countersinks wear down to coincide with the lathe centres (all types of which are specially explained in Chapter III. of the companion handbook), a gradual change of axis will occur. Spring also occurs when the tool pressure is applied. What happens if the end of a shaft is not square across, or is irregular in contour, may be observed in Fig. 5. The support on the centre is more effective on the high side A than it is on the receding side B, and the recess will wear more on the latter. Neglect to face the end across squarely therefore means a non-permanent running attitude on the centres. If sawn, care should be taken to make the cut squarely, while if cut off at the forge, the surface may be trimmed with file or grinding wheel.

Straightening a Bar.—Straightening a bar should follow the preliminary centering operation, which is effected merely to allow the work to be spun between centres to test it for truth. Shallow centre-pops are made as near as possible to the average centre of the rough bar, and the latter being twirled upon the lathe centres is easily checked for warping. Find the centres on the bar ends, lightly centre-pop them, place the piece between centres, and spin it by hand. The high parts are then plainly marked by holding a piece of chalk so that the work may strike it. After this, the bar is removed, and struck upon the anvil, or forced in the bench press, and the testing repeated until correct. One should note at the same time the concentric running of the exterior, and if needed the centre-pops should be driven over to bring the surface approximately right. The recesses are finally deepened and brought to proper shape with a drill or countersink.

To find the centre on the end a number of devices is possible, the principal being illustrated in Fig. 6. On the whitened face four arcs are struck at A with the point of a compass or hermaphrodite callipers, the centre of the group being the spot where a centre-punch is struck and a drill put in. Or a centre-square B is moved round successively, the intersection of the marks giving the centre. Another method calls for the use of **V**-blocks and a surface gauge, the needle of this making four scratches across each end, as represented at C—a good method for massive pieces, and affording a better average of the centre of the whole length of the rough casting or forging. The bell centre-punch D is an accurate device for locating the centre, without tentative markings, and if held upright instantly gives an average centre. The pop should only be a very faint one, which can be subsequently deepened with an ordinary centre-punch ready for the drill. Recently many centering tools have been put on the market, most of them being a combination of the bell-centering punch and a drill revolved by hand or from the lathe or drilling machine, the centering and drilling being thus carried out simultaneously.

When it is necessary to force over a piece of shaft in the lathe while using the square centre, or to force a drill into the central position when starting, a piece of bar is used with a turned-down end. If the operator has a tool-holder in the slide-rest, it becomes a nuisance to have to remove the holder. Fig. 7 shows a fitting to go in the tool-holder, consisting of a stem with a block brazed on, so that the job can be accomplished without removing the tool-holder.

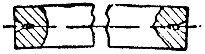


Fig. 4.—Effect of Warping on Alignment of Centres

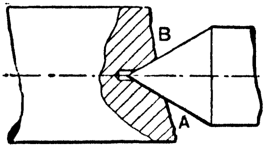


Fig. 5.—Showing that Rough End of Bar Wears more on One Side of Centre

Other devices consist of centering-machines and special adaptations of sensitive drills with centering vices which bring the bar into proper relation to the drill, but they do not come within the scope of this book. A good substitute for bars and discs and pieces that are not too long to hold conveniently in the chuck, or which will go through the hollow spindle, consists in feeding up a drill from the tailstock as the work revolves, thus fixing the centre and making the recess simultaneously. The drill can be held in an adapter or a chuck in the tailstock barrel. Or, to save the time and bother of removing the centre and substituting a chuck, the socket type of holder shown at A in Fig. 8 is handy; it rests against the centre and is clasped by the hand to prevent rotation. For bars that are too long to run in the chuck in this manner, the reverse to this, illustrated in view B (Fig. 8), still enables the drilling to be accomplished without hand labour. The bar with popped impressions is rested against the rear centre, and fed up by it while gripped with the hand.

The centre holes, whether done in the lathe or drilling-machine or with a hand brace, must be accurately coincident with the axis of the work. For this reason the methods given by Fig. 8 are recommended. Lack of alignment would have the same effects as illustrated in Fig. 4. Since the standard angle of 60° has been generally adopted for lathe centres, the drilling has become simplified, for standard countersinks can be purchased, while the Slocomb pattern of combined countersink and drill is still better, as it saves time and makes certain of an accurate and neat centre recess.

Work must never be run on the centre in the way shown at A (Fig. 9), even though the angle of the recess matches that of the centre. The contact of the point of the latter at the bottom of the hole wears the point of the centre rapidly, and true running for any length of time is impossible. Moreover, lubrication will be imperfect, and the friction and consequent

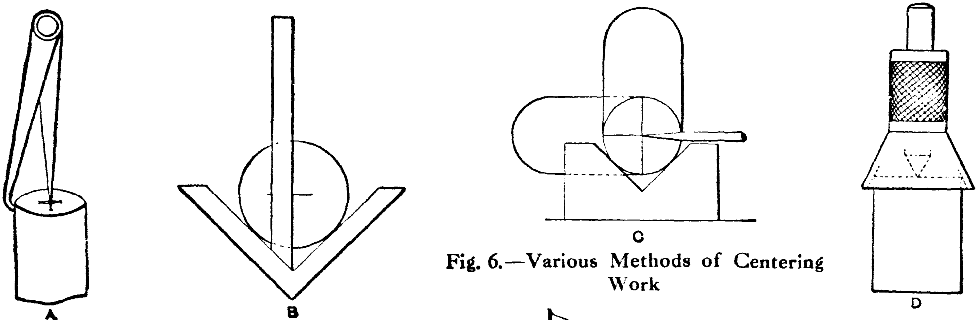


Fig. 6.—Various Methods of Centering Work

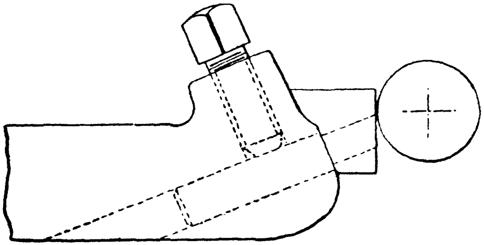


Fig. 7.—Forcing Bar Fitted in Tool-holder

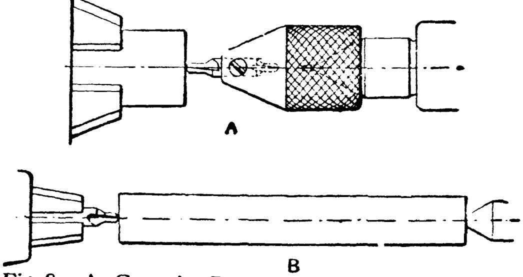


Fig. 8.—A, Centering Bar in Chuck with Loose Drill-holder; B, Centering Long Bar from Headstock

heating soon roughs up the centre and leads to trouble. The centre hole should be as at B, fitting the cone of the centre exactly, and having a clearance hole of sufficient length to clear the tip and allow for possible wear during turning. If the angles do not match, as in the variety of ways shown at C and D, the first contact will be on lines only, and subsequent wearing to a fit will tend to heat the centre and piece, and may result in a displacement of the work axis during the change. Of the two faults, C is the least troublesome, because the bearing diameter is larger, and so a steadier effect is obtained.

Equally unsatisfactory results may occur when the conical centering and cylindrical holes do not coincide, as shown by Fig. 10. It will be evident that by screwing up the lathe centre into such a hole one of two evils must be created. If the work is of slight character, or weak in cross section, such deviation of axes will tend to spring or distort it; while if the work is too stiff to be thus sprung, the unequal bearing and diminished contact will quickly tend to wear either the lathe centre or the work.

A rather old-fashioned procedure for putting in the countersink is the employment of the square centre, which was in greater favour before the advent of the Slocomb drills. In this method a starting hole is drilled in the centre, and the work is then mounted in the lathe and revolved, the square centre being put into the tailstock barrel. Its edges cut into the bar and form the countersink on feeding up with the handwheel. The special value of this appliance is to bring work to run truly when the centering happens to have been done out of truth, to correct worn centre holes in such a way that the shaft will again revolve truly on them, or to alter the running of a rough bar, forging or casting, so that certain sections of it will clean up all round. For this correction it is necessary to use a pressure or forcing bar in the slide-rest, either a plain bar or a forked bar A (Fig. 11). The work is forced by suitable manipulation of the cross-slide handle.

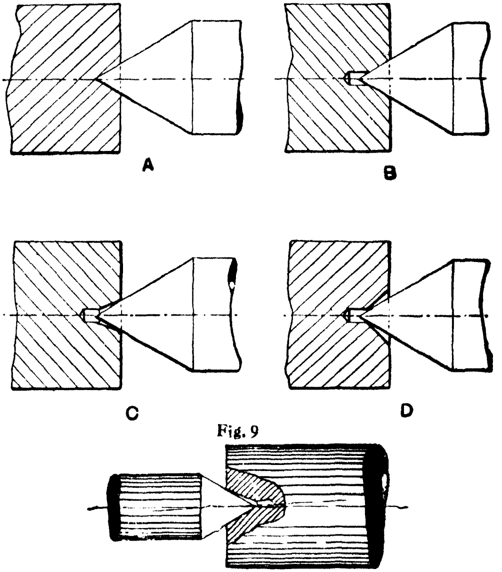


Fig. 9

Fig. 10

Figs. 9 and 10.—Correct and Incorrect Centre Bearing

The square centre is prepared similarly to an ordinary one, and then ground carefully with four flats (Fig. 12), taking care not to alter the cone angle at the termination of the grinding. An alternative mode of formation is to cut away half of a centre; this gives a free-cutting instrument, but it must be used carefully to avoid producing an irregular shape of recess. The half-centre is shown in Fig. 13.

Methods of Finding Centre Height.— A rough-and-ready method of finding the centre height of a piece of work in the lathe to set the tool to is that shown by Fig. 14. Apply a square, standing the stock on the bed, bringing the blade into contact with the periphery of the work. The point where the two touch will be the height to which the tool may then be adjusted. The method is useful in cases where a slide-rest height-gauge cannot be conveniently applied, and also for the American type of tool-post.

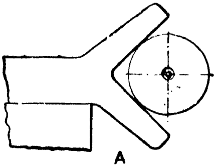
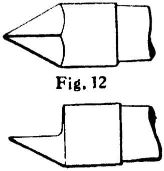


Fig. 11.—Forcing-bar



Figs. 12 and 13.—Square and Half centres

The adjustment of a cutter for height of centres is usually done by a gauge laid on the slide-rest top, or on the tool-holder itself. A very simple device, which requires the minimum of time to apply, is that illustrated by Fig. 15. This consists of a knurled ring, the thickness of which equals the height of the cutter-nose from the face of the holder.

Running on Centres.—If the centres are hardened and accurately ground and the ends of the work are correctly prepared, no trouble should be experienced in starting up and turning. The only risks which may be encountered are those of expansion endwise, and of heating, which latter is induced either by the expansion or through lack of sufficient lubrication. The expansion takes place through heat evolved in turning, often through neglect to use a cutting lubricant on the surface. In the case of materials that do not require lubricant (lubricants are fully discussed later on), the heat may be kept down by running at a slower speed, or by a better shape of tool. When a shaft becomes too long for the distance between the centres it starts to bend and whip round, and the turning on it will obviously be inaccurate.

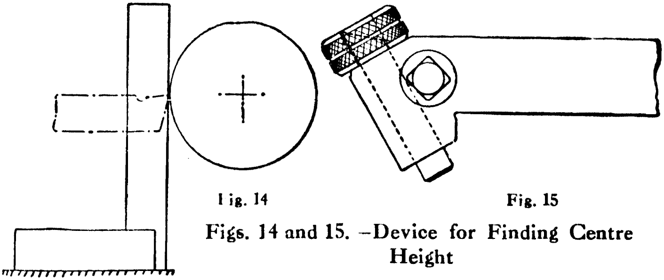


Fig. 14

Fig. 15

Figs. 14 and 15. –Device for Finding Centre Height

Lubrication of the centre is also important, and the safest plan, if the turning is of long duration and the pressure heavy, is to apply a thick grease, or a mixture such as graphite and tallow, or white lead and oil.

Of course, the pressure of the tailstock barrel must not be changed while a cut is in progress, or the diameter will alter, but opportunity should be taken before starting a fresh cut to slack off the centre and get in a fresh supply of oil or grease. An important point in connection with the friction of centres is the direction of feed. When the tool is fed away from the headstock, the force of the feed adds extra pressure on the tailstock centre, but with the feed run the other way the thrust comes on the running centre.

Mounting Tubular Work on Centres.—Tubes and other pieces with large bores cannot be supported on the standard centres, or on the enlarged centres mentioned previously if the interiors happen to be rough and out of round. Bridging is then necessary for the purpose of providing an artificial surface into which the countersinks may be put. For brief periods of turning it is satisfactory to fit hardwood blocks in the ends, and let these run on the centres. For durability, centre-plates may be screwed on the faces of the blocks.

Properly fitted metal bridge-pieces will last for a long time and keep the work running true, but there is danger of not fixing them firmly enough, and of getting too tight a fit, so that the tube is distorted out of round. A slight taper on the ends of a strip (A, Fig. 16) is made to let it drive in with sufficient permanency during the turning operations. Thinness of the walls renders such a narrow strip undesirable, for the reason that the pressure is too localised. To spread it round the circumference should be the aim, and this is done by widening it, by using a complete circular piece, or three or four contact points, as shown at B. Spiders with means for adjustment to various bores are useful for this purpose, the construction being as shown by C. Adjustment of the screws provides sufficient grip without distortion, and relative settings of each screw enable the countersink to be brought to the central position. In some circumstances it is required to set the outside running true, for the purpose of skimming out without reference to the inside, while in others the inside is set true before the turning commences.

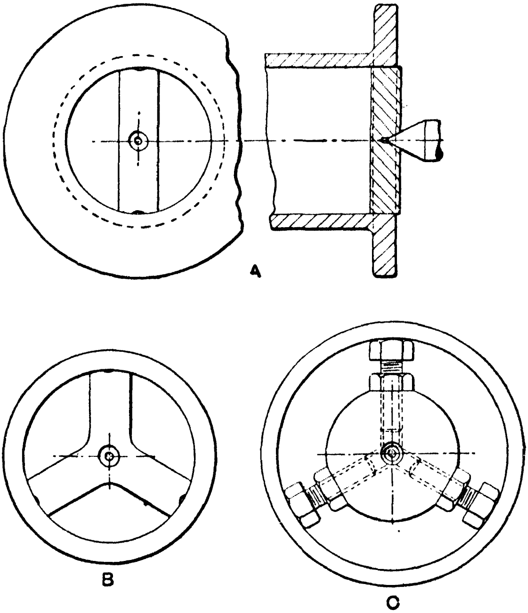


Fig. 16.—Methods of Running Tubes on Centres

Recessing and Undercutting.—Recessing is performed either on diameters or on faces. In the first instance the ordinary parting tools are appropriate, being fed in accurately to depth by a gap-gauge test by means of the control of a stop on the cross-slide, or by reading the micrometer on the feed screw. Face recessing is not quite so simple, because of the interference of the curves with the tool clearance, a difficulty which becomes accentuated on the smaller curves. The flank clearance has to be ground amply to avoid fouling the surfaces. A similar problem has to be countered when undercutting shoulders, and the tool must be bent, usually at right angles (Fig. 17), for projecting the end out from the slide-rest into the work; the amount of cranking depends upon the work in hand.

Knurling.—This operation comprises two or three variations in the mode of applying the knurling tool (details of knurling tools are given in Chapter XI.). On narrow bands not wider than the width of the knurl wheel the work consists in simply feeding straight in, revolving the work slowly, keeping the back centre well oiled, and applying the pressure until a perfect formation has been obtained. Lengths exceeding the capacity of the wheel are either divided up into successive bands by a grooving tool, after which the knurling proceeds on each band as just described, or a very slow self-acting feed is thrown in to travel the tool along continuously.

Chamfering the Ends of Work.—Work running on centres, such as bolts, pins, shafts, etc., cannot be so conveniently chamfered or rounded on the ends with the ordinary tools, nor with those of double type (*see* Chapter V.), because of the obstruction of the back centre. Even with a cut-away centre the operation is not easy, and the best way is to use special one-sided tools made as shown by Fig. 18. These are also suitable for nut chamfering on various sizes of nuts.

The Use of the Hollow Lathe Spindle.—Where a number of parts have to be produced from rod a long length is passed through the spindle and gripped in the chuck. Each piece is pushed through to the requisite length by means of a stop piece held in the tailstock spindle. As each piece is finished and cut off the chuck-jaws or collet-jaws are released and the rod pushed through to the stop; thus are all pieces assured of uniformity of length. For actual details of hollow-spindle lathes reference should be made to Chapter II. of the companion handbook.

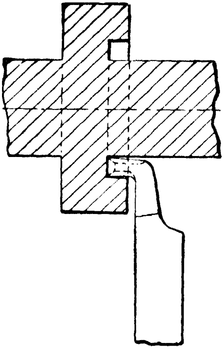


Fig. 17.—Undercutting Operation

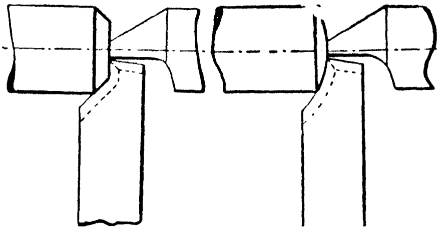


Fig. 18.—Chamfering and End-rounding Operations

Lubricants Used in Metal Turning.—It is desirable at this point in the instruction to enumerate the various lubricants used in metal turning for lubricating the cutting tool.

Lard is used for turning, chucking, drilling, milling, and tapping tool steel, lard oil being used for reaming this metal.

Tool steel is sometimes turned dry, when the diameter and speed is reasonably low (*see* Chapter XII. of "The Simple Lathe and Its Accessories," which fully deals with the question of speeds and feeds), and soda water is used in some factories for chucking in place of lard.

Lard is also used for drilling, milling and tapping soft steel, chucking copper, drilling and milling wrought iron and copper, and for tapping wrought iron, cast iron, brass, copper and babbit.

Soft steel, cast iron, wrought iron, brass, copper and babbit are turned dry, although soda water can with advantage be used, in some instances, for turning soft steel and wrought iron.

Soda water is used for chucking steel and wrought iron, and for drilling and milling soft steel and wrought iron.

Lard oil is used extensively for reaming tool steel, soft steel and wrought iron.

A mixture composed of crude petroleum and lard oil is used for reaming copper.

Babbit can be reamed dry or with paraffin. Cast iron and brass are reamed, milled, drilled and chucked dry. Babbit is also chucked, milled and drilled dry.

There are several cutting lubricants such as "white water" sold for the purpose; they are applied to the cutting edge of the tool either by means of a pump worked from the lathe spindle, or by means of a tin filled with the liquid and provided with a tap so that the supply may be regulated.

With regard to the rate of flow, this must be adjusted to suit the work. In boring and drilling a fast supply should be kept up, so that swarf and chips are washed clear of the work to avoid "crowding."

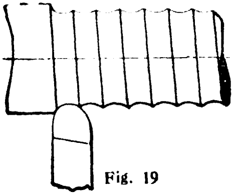


Fig. 19

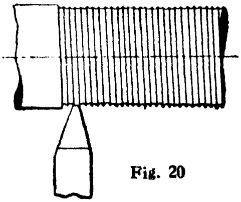


Fig. 20

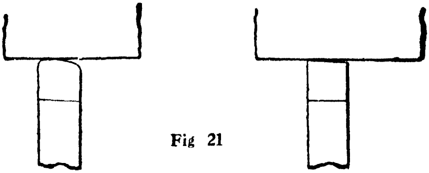


Fig 21

Figs. 19 to 21.—Effect of Coarse and Fine Feeds

The Roughing and Finishing Cuts.—The distinction between a roughing and a finishing cut is chiefly that of depth of penetration and amount of feed. Normally a roughing traverse means a deep penetration and a coarse feed, while a finishing traverse embodies a light cut and slower feed. This is not a hard and fast rule, since "finish" is a relative term, and some articles can be finished with tools like those in Figs. 154 to 156 in Chapter XI. of the present handbook (wherein surface speeds and feeds are also discussed), given a suitable rate of feed, even though the depth of cut be very pronounced. What happens with a tool having a point or a round nose is the evolution of a spiral outline of the surface; this may be coarse, like Fig. 19, or fine like Fig. 20. The more pointed the tool the finer the feed needs to be (refer to Chapter XI. of "The Simple Lathe and Its Accessories"). By placing the flat curve of a tool nearly parallel with the axis, or doing the same with a flat-edged tool (Fig. 21), the elimination of the ridges is guaranteed. The flat-edged tool usually supplies the best method of finishing. It is a difficult matter to adjust the edge nearly parallel with the work axis in order to secure the best results, for there is a point at which chatter is apt to develop. This is why the spring or goose-neck principle has to be adopted. This (Fig. 22) permits of a little elasticity, and enables a smooth surface to be turned.

A method adopted by some operators is to insert a piece of rubber in the loop, which softens the spring action and lessens the chattering. Care has to be exercised in the use of this tool or the work will not be round, because it yields so easily against the harder spots in the metal. Crank-pins on bent cranks have sometimes been finished with such a tool and then found to be quite elliptical, partly due to the spring of the tool and partly because of the lack of proper balancing of the crank on the centres.

An expert workman roughs down to a close approximation of the finished size, and accomplishes the final reduction at one cut. This is safer and better than leaving two or three traverses for the finish, which not only acts unfairly upon the finishing-tool edge, but is liable to cause chatter. It is often found that a finishing-tool will act perfectly in running along for the first time on the slightly ridged surface of a roughed-out shaft; but on a second or third cut the contact of the longer finishing edge causes trouble by chattering, and then the turner has, perhaps, to eliminate the marks by setting the tool to cut more at the point, and so a lot of time is wasted.

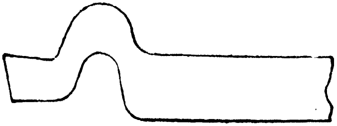


Fig. 22.—Spring Tool

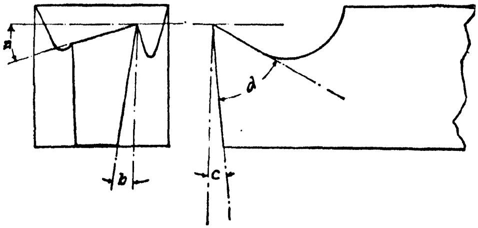


Fig. 23.—Tool Angles *(See table below)*

Gunmetal		*Cast iron*	*Steel*	*Wrought iron*	*Brass*
a	5°	15°	20°	25°	10°
b	3°	3°	3°	3°	3°
c	3°	3°	3°	3°	3°
d	85°	70°	60°	56°	80°

The Depth of Cut. — The heaviest cut is that which may be made without breaking the belt or pulling it up, and also without giving excessive vibration. Provided that these rules are observed, the heaviest cut is that which removes the greatest amount of material in the shortest possible time. There are many who assume that by running a machine slow and increasing the depth and width of cut a greater amount of metal is removed in a given time, whereas often it may be found that by decreasing the depth or width of the cut and increasing the speed a greater amount of metal is removed.

It may be said that for heavy cuts the belt speed should be high, the tool should be of high-speed steel, well lubricated, and also rigidly supported in its rest.

As the best work can only be done with a correctly ground tool, it will be found advantageous to make a standard set of gauges in tinplate, to which the tool should be ground. Fig. 23, which should be referred to in conjunction with the table beneath it, shows the average best angles for various metals. It will, of course, be understood that in certain cases these angles will have to be departed from.

For very full information on cutting tools, angles, feeds and speeds, the reader is referred to Chapter XII. of the companion handbook, " The Simple Lathe and Its Accessories."

Hand Turning.—Hand-turning tools differ in many respects from fixed tools in that their cutting edges are usually given a different angle; they do not need so great a body of metal to back up their cutting edges in order to give them strength and rigidity, and their shape is usually a departure from the latter owing to the different manner of manipulating them.

The three principal tools used in hand turning are the graver (Fig. 24), the triangular tool (Fig. 25), and the hook tool, sometimes termed a heel tool (Fig. 26), all being suitable for iron or steel. For brass or gunmetal the round nose (Fig. 27), the flat (Fig. 28), and the square end (Fig. 29) are the usual shapes in practice. Fig. 30 illustrates another form of tool used for iron or steel, and which is eminently suitable for getting into hollows of small radius or working round beads, etc. The parting tool (Fig. 31) is, as its name implies, more often used as a single-purpose tool, namely, for parting off work of a cylindrical character, but it may also be used with equal success in square recesses, such as piston-ring grooves or for squaring up the ends of round stock held between the centres. Tools used for brass need a considerably less clearance angle than for iron or steel. The two most favoured shapes in this respect are shown by Fig. 32, where the first illustrates the amount of clearance needed for iron; the second tool is for brass, and does not have top clearance.

Worn out files are often used for making these tools, these being as serviceable as new material and certainly less costly.

It is necessary in every case to provide a longer handle to the hook tool, since the danger of digging into the work is immeasurably greater than with the other shapes, hence a longer leverage is absolutely essential to overcome this tendency. A handle not less than 12 in. long should be used.

With both brass and iron turning it sometimes happens that it is required to bore out or end-recess a piece of work, which by reason of its formation or shape will not accommodate itself to the reach of an ordinary tool-rest. When such is the case, it is usual to have recourse to the tool known as the arm-rest. As shown by Fig. 33, this is a bent steel tool ½ in. by ¼ in. in section, one end of which is upturned ½ in., the other end driven into a long, stiff, parallel handle about 15 in. or 18 in. long. In use, this is held rigid under the left armpit, its steel end resting across the tool-rest and projecting therefrom such a distance as will permit the turning tool being used axially with the work, the tool taking its pressure and being supported from the end of the arm-rest. This arrangement is shown in Fig. 34. Fig. 35 shows two bent forms of tools which render the operation of boring or recessing less difficult than would be the case if tools of a straight form were used.

A set of hand-turning tools would be considered incomplete without a planisher or burnisher. This is shaped something like Fig. 36, its end rounded as shown. filed perfectly smooth, hardened, and then given a perfect deep polish on a piece of buff leather, using crocus powder as an abrasive medium. This tool is used for imparting a brilliant surface finish to the work, and in use is pressed against the underside of

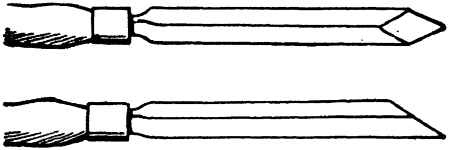


Fig. 24.—Gravers for Hand Turning

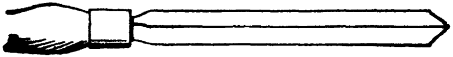


Fig. 25.—Triangular Tool

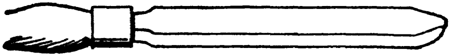


Fig. 27.—Round-nose Tool

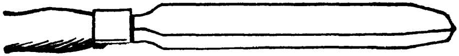


Fig. 28.—Flat-nose Tool

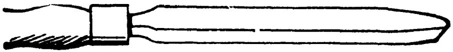


Fig. 29.—Square-end Tool

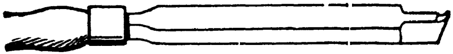


Fig. 30.—Tool for Working Beads and Hollows

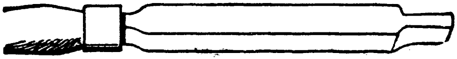


Fig. 31.—Parting Tool

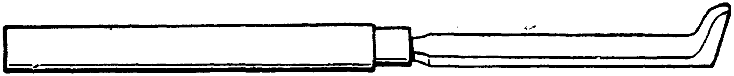


Fig. 26.—Hook or Heel Tool

the work whilst revolving at top speed, the rest serving the purpose of a fulcrum.

Having described the tools necessary to hand turning a few hints on their application will now be given. For reducing work from the rough stock it is the usual practice to begin with the hook tool (Fig. 26), this being the most powerful of all hand tools. The correct position to hold this, relative to the work, is with the front face almost tangential, as shown by the dotted line in Fig. 37. The incorrect and dangerous method is as shown in profile.

The movement of a hand-turning tool for iron differs altogether from the movement required when turning wood. In the latter the tool is moved bodily along the rest as the cut proceeds; in the former a semicircular, sweeping movement is given it, using the heel of the tool as the centre about which the cutting arc of the tool travels. When the full reach of the tool is attained, it must be moved along the rest to start a further movement.

The triangular tool has three cutting edges, each of 60° angle. If means are to hand for slightly curving these lengthwise, converting the flats into convex faces, the efficiency of the tool will be considerably enhanced. It is held in position a little underhand; that is, with the handle end highest, and the point of the tool slightly above the centre line of the work, as in Fig. 38. Thus the cutting strain is counteracted by depressing the handle, the rest, as before, forming the fulcrum.

The graver is more or less a finishing tool, its

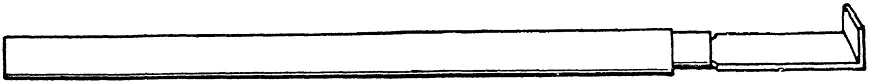


Fig. 33.—Handled Arm-rest

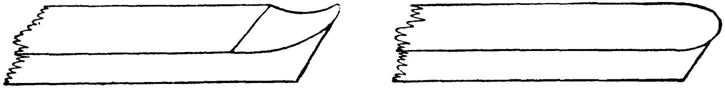


Fig. 32.—Tools Ground for Turning Iron and Brass Respectively

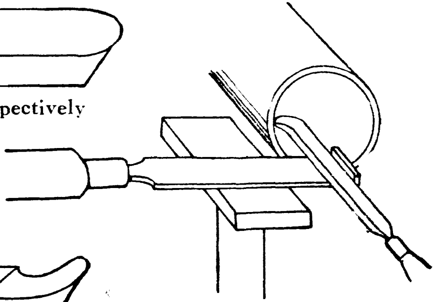


Fig. 34.—Use of Arm-rest

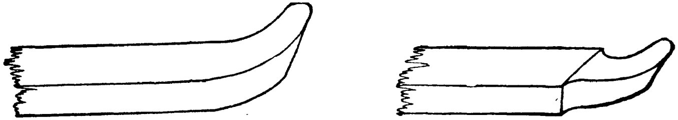


Fig. 35.—Hand Tools for boring

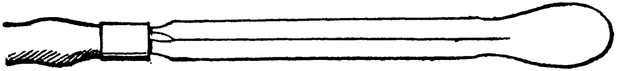


Fig. 36.—Burnisher

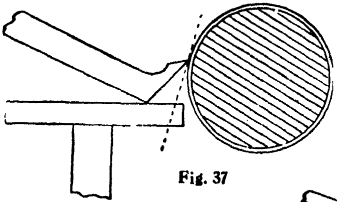


Fig. 37

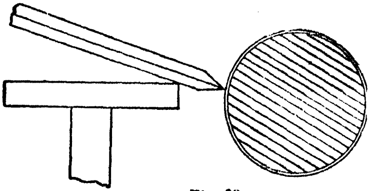


Fig. 38

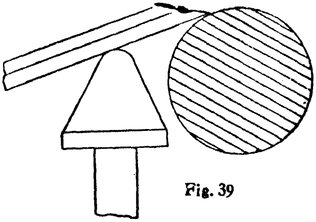


Fig. 39

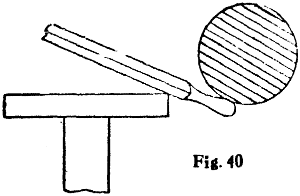


Fig. 40

Figs. 37 to 40.—Various Positions of Hand-turning Tools

purpose being to smooth down the rings of ridges left by the previous tools. Also it is used rather differently as regards angle. If nicely ground, its edges finished on an oil-stone, and held as indicated in Fig. 39, it will peel off a beautifully thin shaving almost the width of the cutting edge, without distressing the tool in the least, and demanding no appreciable effort to keep it to its work, its advantage over the flat types being apparent. Moreover, it is possible with the graver in the hand of an expert to take a sliding cut as in turning wood.

Fig. 40 represents the relative positions of work, rest, and tool when burnishing.

CHAPTER II

Chuck and Faceplate Work

THE reader is referred here to Chapter IV. of "The Simple Lathe and Its Accessories" for details relating to actual construction of chucks.

The Applications of Chucks. — The tightening down of a jaw upon an inadequately supported section of metal must always be guarded against, or the result will be distortion or fracture. To apply pressure too near to a thin edge is dangerous, while when there is an opportunity of gaining the assistance of a rib or arm to resist the pressure, the chance should be taken advantage of. For an example of this important fact, a wheel or pulley is the best selection. Pressure directly in line with the arms (*see* A, Fig. 41) is the correct disposition, and not as shown by the dotted arrow (*see* B). Similarly when internal gripping is done, the jaws should be set close to the arms (*see* C), and not at intermediate locations between them.

Occasionally it becomes practicable to offer stiffening resistance in the way of struts or filling plugs or pieces, taking due care that these are not forced or hammered in too hard. Sometimes a regular mandrel is convenient (*see* Chapter VI. of the companion handbook), completely filling the bore of a thin tube. Rings can then be cut off, or the ends of the tube trimmed.

An occasional dodge lies in stopping local pressure of the bites by encircling a thin tube with a ring, split at one portion of the circumference to allow for the closing in.

This kind of extension of pressure area is likewise valuable in other circumstances, such as to bridge over openings which detract from the total gripping capacity of the jaws. Such a state of affairs occurs in Fig. 42, where a very tight hold is required to present the overhanging bracket for facing the foot.

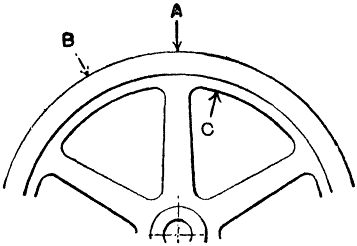


Fig. 41.—Correct and Incorrect Spots for Jaw Pressure

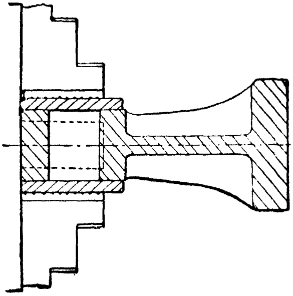


Fig. 42.—Flanking Plates to Assist Grip

The loss of chucking area incurred by the presence of the cast hole in the boss is compensated for by laying rough plates of iron across each face as shown, and pinching the jaws down on these. In this instance a four-jaw independent chuck is used, and the two other jaws at right angles are set up against the sides of the boss for additional steadying effect.

Specially high tailstocks, standing out farther from the chuck face, provide a useful supplement to the holding power of the jaws, and resist the lateral forcing induced by cuts on extended parts of the job. Other methods of solving these difficulties are by gaining tailstock support and by clamping-plates. The former generally means fitting bridge pieces, unless the end of the work happens to be solid, or possesses an opening suitable for running on the large head centre. Clamps from the chuck are applied similarly to those used in faceplate holding methods (*see* Chapter V. of "The Simple Lathe and Its Accessories"), and when set upon a foot or flange retain the same in the chuck jaws in a positive way against wrenching-out tendencies.

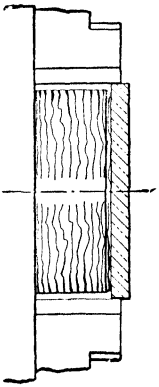


Fig. 44

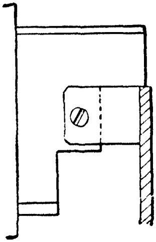


Fig. 45

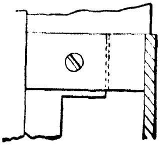


Fig. 46

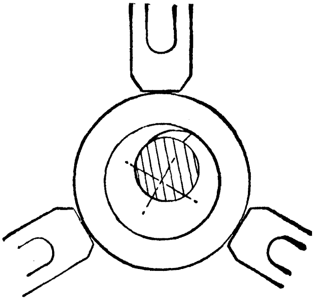


Fig. 43.—Use of Packing to Set Piece Eccentrically

Figs. 44 to 46.—Methods of Packing-out Thin Work

It should be noted that the value of a concentric chuck is not confined to strictly concentric running, but it is available for eccentric purposes by the simple expedient of interposing a strip of packing between one jaw (in a three-jaw chuck) and the object. Fig. 43

gives the principle diagrammatically, and shows how the falling away of the curve of an eccentric from the one jaw is made up by a liner of suitable thickness. The chucking can be repeated as often as desired on similar diameters with the same packing.

Another dodge, sometimes extremely handy, involves the use of a short piece of round tube, split through, and utilised for gripping certain sections of rods or castings, etc. Thus a square bar can be held concentrically in a three-jaw chuck by this device, the three jaws bearing on the exterior of the tube and compressing it around the corners of the square. Or a hexagon section is capable of being similarly run truly in a four-jaw chuck.

There is on certain occasions a difficulty with regard to the chucking of thin flanges, washers, discs or plates, which if pushed right up to the jaw faces cannot be tooled right to the edge. If the endeavour is made to adjust them close to the jaw edges, this usually gives rise to difficulty in setting accurately, and the hold is uncertain, as one never knows when the work is going to slip inwards at one or all of the jaws under the force of the cut. Here is a case for packings to oppose their solid resistance to the thrust. The shape of these varies with the class of hold, comprising forms such as in Figs. 44 to 46, which show a plain wood disc, a metal blocking on a jaw, retained in place with ears and a screw, and a modification of the same block carried down to the chuck face.

Balance-weights.—The centrifugal force induced by a lop-sided shape tends to prevent true circular running, and the contour of turned or bored surfaces may be oval or elliptical instead of circular. To remedy the evil, a balance-weight of sufficient mass must be bolted to the side of the faceplate or chuck which is opposite to the excess of metal, so as to obtain an approximate balance. Perhaps the only instance where it becomes unnecessary to provide for an unbalanced job is where what may be termed "arc turning" is performed; that is, only a part of the periphery or face of an article is tooled, either because such an area is the only part needing machining, or from the impossibility of making a complete revolution of the work without fouling the tool or slide-rest. Fig. 47 shows a job set up on the faceplate and balanced with an odd clump of metal.

Special Jaws.—In rare cases the four-jaw independent chuck cannot be successfully gripped on to a piece of work because of the presence of a projection that comes in the way of one jaw. Should the concentric three-jaw chuck not be strong enough or large enough to tackle the job, or the independent setting of the other chuck jaw is imperative, a method of solving the difficulty is to run out one jaw, and substitute a dog with screw, or a simple stop-plate at the nearest convenient hole or slot on the chuck plate. The fourth bite can thus still be secured.

Stops.—When one has to work the tool close up to jaws, a safe plan is to fix a stop firmly on the bed to check the travel of the saddle beyond the danger point, and if necessary one for the top slide as well, so that no mischance or accidental catching of the clothes in the handles can bang the tool against the revolving jaws and inflict damage.

Leaving Jaws in Same Position.—If a number of similar pieces have to be held in the four-jaw independent, for boring or turning operations, a time-saving hint is to leave two adjacent jaws always untouched, and loosen and tighten the other two for the handling of each article. This locates the position automatically and saves time in tentative centerings. In such a case the two fixed jaws may be specially marked by chalking round their screws or sticking stamp-edging over them. The idea is also useful for eccentric settings, to bring easily a hole in an eccentric piece correct for boring, or to turn a boss out of centre.

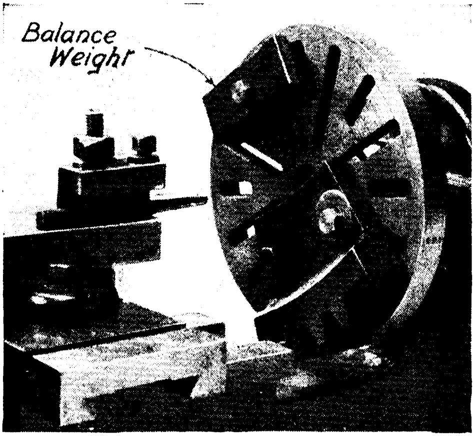


Fig 47.—Balance-weight on Faceplate

The Use of Angle Plates.—One device which enables an accurate centering and alignment of a bore to be made embodies the fitting in of cross-bars at the mouth of the hole at each end, and the striking of centres on these. The end next the faceplate is now centred by observing the coincidence of the point centre with the mark on the cross-bar, while at the front end the tailstock centre fulfils a similar function. The clamping is then carried out at this setting. Often a simple trial with a square laid against the faceplate suffices to set a rectangular shape true on the angle plate. In other examples reference is made to a circle struck on the front part of the work, with or without tests, by means of a square for the alignment. By stringing a bored job upon a mandrel, placing the mandrel between centres, and bringing the angle plate up against it, carrying out the clamping carefully, and then withdrawing the mandrel, a perfectly concentric rotation is obtainable where it is imperative to chuck with such hole as a starting-point. The mandrel must only be a sliding fit, for ease of removal. Re-setting to fresh centres for dealing with two or three parallel bores and facings need not always mean that the clamping appliances must be released and set up afresh, for it is often more convenient simply to loosen the angle plate, and slide it to right or left or up or down the faceplate, a mode of adjustment which preserves the alignment and parallelism of the work. Examples of angle-plate uses are suggested in Figs. 48 to 50 (*see* also Chapter IV. of the companion handbook). The first is a very plain case, without even any clamps, because the foot of the bearing receives the holding bolts. Where such a fixing is not feasible, a clamping plate might be passed across the top and pulled down with a bolt at each end. Circular-bodied castings demand **V**-blocks for safe chucking (Fig 49), and if more than one similar shape has to be treated, it pays to clamp the blocks independently of the work, whereby the centering and location of the next specimen is ensured immediately. The application of plain packing for the purpose of raising a flange to clear the angle plate may be noted in Fig. 50.

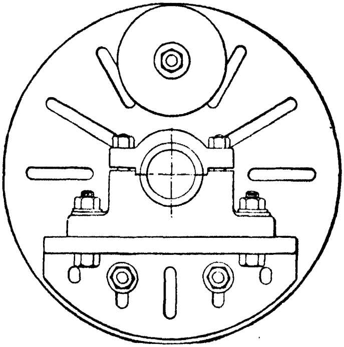


Fig. 48.—Bearing Housing mounted on Angle Plate

The Use of Knife Tools.—Given plenty of space to angle the tool and to manipulate the slide-rest, facing operations can be accomplished with the ordinary turning tools, straight or bent and round nosed or diamond pointed. (For details of these tools refer particularly to Chapter XI. of the present handbook.)

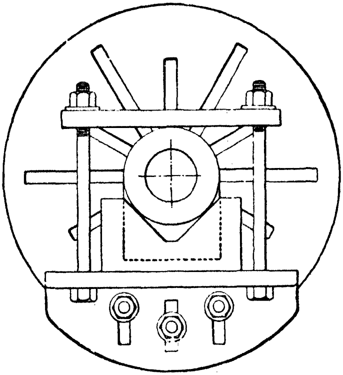


Fig. 49.—V-blocks and Angle Plate used tor Chucking

But a more convenient tool for facing where space is restricted, as between flanges or on short work, or at the end where the tailstock is apt to come in the way of the tool or rest, is the knife or side tool. This provides a long stiff edge with thin point, and it is gripped in the rest practically at right angles to the axis of the lathe. The slight deviation from a perfectly square setting is requisite to prevent the whole length of the edge coming into contact with the work and causing a dig-in or chattering. These tools are made left and right hand, A and B (Fig. 51). For occasional service in awkward corners, and where a chuck or carrier would come in the way of the slide-rest, the bent shape as at C is utilised. Fig. 52 shows the knife tool facing true the ends of a bush, which is driven on a mandrel and mounted between centres.

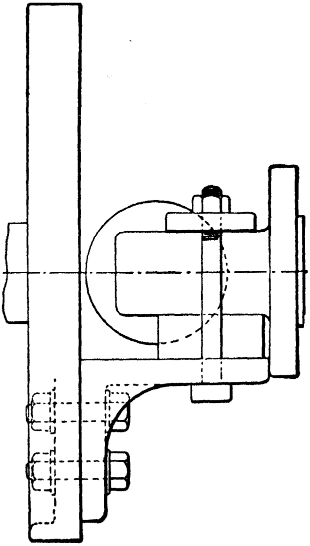


Fig. 50.—Diagram Showing Use of Packing on Angle Plate

The production of a number of similar collars, washers, or rings is assisted by the use of double-facing or knife tools, clamped in the slide-rest and carefully adjusted to cut to the prescribed width. For the finer classes of work they need to be alike in clearance and cutting angle, also in sharpness, because one tool which is blunter or duller than the other becomes pushed away from the side of the work; the better tool cuts in more freely.

Double Facing-tool.— Fig. 53 illustrates a double facing-tool for repetition work, the cutters being set to a gauge or specimen, and retained by the set-screws. A balanced cut is obtained, and the outfit may be taken away and replaced at a moment's notice without the trouble involved in carefully adjusting separate tools. A narrow form of tool for thin work only is constructed with a shank not enlarged into a fork, but carried out to the nose to the same diameter, split through horizontally, and fitted with a set-screw to contract the split end, which grips the cutters within shelves or notches on either side. When facing has to be done on small diameters, soft material or tubing, the use of a parting-tool often suffices instead of the knife tool or a

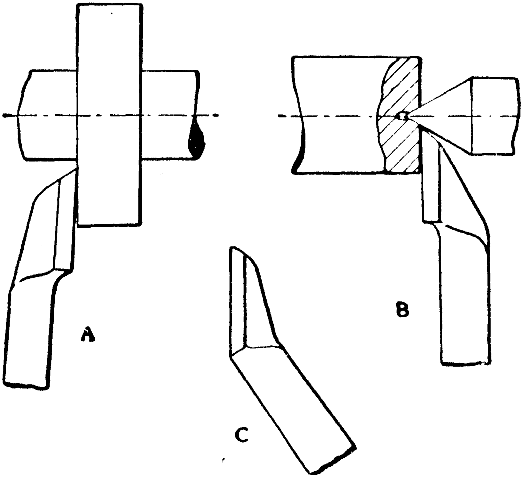


Fig. 51.—Knife Tool Applications

turning-tool set angularly. The advantage of the parting-tool is that it can be made to cut to right and left hand, and also to perform grooving, shouldering, etc., without change of position in the slide-rest.

Parting off.— This operation is often a strenuous one for the tool, which has to endure severe and continuous pressure as it is fed straight in. Placing the tool point above the centre is also a source of risk, because the bending down which takes place as the cut develops thrusts the edge still deeper into the metal instead of away from it, as when the point is level or below centre. Careful manufacture is, moreover, imperative if parting-tools are to work successfully, especially in deep cuts. Grooving is an exactly similar process, and the foregoing remarks refer to tools for this as well.

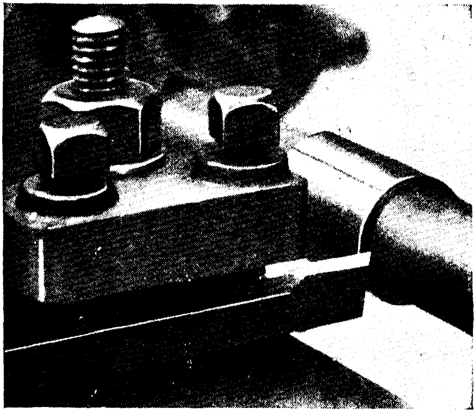


Fig. 52.—Another Application of the Knife Tool

In the first place, the bottom of the tool must be flat, or even a little concave, in order that it shall stand firm and not tilt over and interfere with the clearance on one side. Having the bottom thus correct to stand the tool perfectly upright, the flank clearance requires to be equal on each side, 2° to 3° being sufficient (Fig. 54). A little relief from the point backwards is also necessary to prevent the tool from binding in the cut. The dotted outline of a curve on the nose indicates how top rake is sometimes ground, but everything needs to be in good order when this is done, otherwise a dig-in will result. The reader is again referred to the very full discussion on the fundamentals of cutting tools and holders in Chapter XI. of the present handbook. Off-set parting-tools become essential when the ordinary central-blade type cannot be approached to the cut owing to the presence of a shoulder or projection or the interference of chuck jaws. The off-setting is done to right or left hand A (Fig. 55),

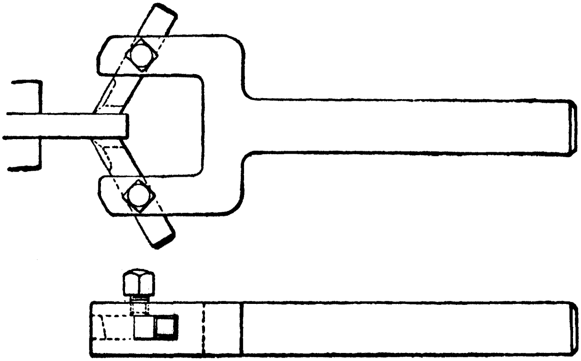


Fig. 53.—Double Facing Tool

while bent tools B are applied in other cases where these are not available or an angular cut is required.

For parting-off tubes a difference may be advantageously made in the shape of end, as represented in Fig. 56, the idea of the bevel being to finish the end of the cut off portion A neatly without a burr before it drops off, after which the tool goes farther and trims the end still in the chuck.

The same principle is illustrated in Fig. 57, the particular tool shown having two shoulders instead of one. In making such a tool, see that the cutting end is sloped, and the result, as already explained, must be that the piece falls off with the minimum of burr (or with none at all if the corner of the tool is quite keen).

Another hint in connection with this work is that of using a pair of tools (Fig. 58) set accurately to the length desired for the piece and fed in as shown. The tube or rod is drawn out from the chuck each time to a shade farther than the length indicated, so that the outer tool shall shave off just a fine amount.

The use of a long blade of uniform section in holders supplies a convenient mode of obtaining the section suitable for cutting off; the projection can be restricted to suit the diameter being operated on, and in case of breakage less trouble is incurred than is the case with forged or ground tools having wider shanks. The holder takes the place of the shanks in providing a stiff support with sufficient width of base, and the actual blades may be very thin; for light work old hack-saw blades suitably ground are excellent.

Fig. 59 is a simple class of holder adapted for thin

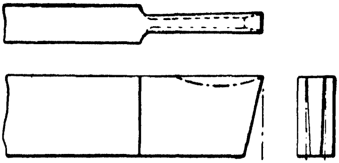


Fig. 54.—Parting Tool

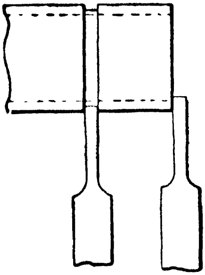


Fig. 58.—Two Tools Set for Cutting Uniform Lengths

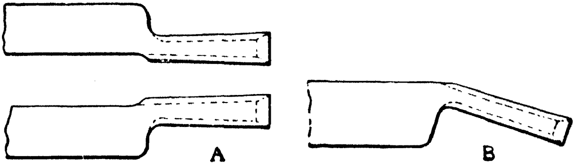


Fig. 55.—Off-set Parting Tool

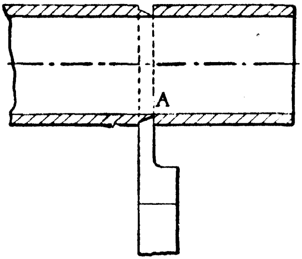


Fig. 56.—Parting Tool with Bevel End

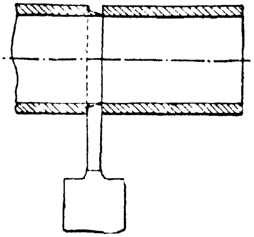


Fig. 57.—Parting Tool Ground to Avoid Burr on Piece

blades, and is made by sawing a groove in a strip of steel or brass, and tightening the sides upon the blade with the three screws. Clearance is ground on the cutting end, as stated above. The Squire holder (Fig. 60) is built in halves, joined by screws, as apparent from the view, with a strong clamping effort at the end.

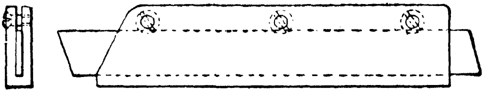


Fig. 59.—Small Parting-tool Holder

Off-set holders present the blade at one side clear of screws, clamps or other fixings, or with at least a very small projection, so that cutting off can be effected close up to the chuck. The usual device is that of a top clamp forcing the blade down into the body of the holder. Or the latter is formed of top and bottom portions, and the edges of the blade are bevelled (Fig. 61), so providing a pull-back action when the top is screwed down.

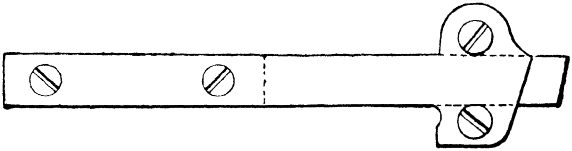


Fig. 60.—Squire's Divided Tool Holder

The Burnerd cutting-off tool (Fig. 62) is designed to prevent the troubles that arise from parting-tools digging in. There is a stout angle-piece affixed and adjusted until its arm suits the radius of the bar to be cut off. If the tool attempts to dig in the angle-piece prevents it.

Cutting-off is occasionally performed (in connection with a chamfering or rounding operation) with one tool specially shaped. The object of this is to complete the head or end of a screw or pin practically to its finished outline without going to the trouble of a re-chucking and separate tooling. The pieces are turned from bar passed through the chuck, and the parting tool is made on the end with the usual narrow blade to the left, extending on the right to a bevelled or curved profile, which will turn the head appropriately and finish it to shape just before the parting portion severs the material.

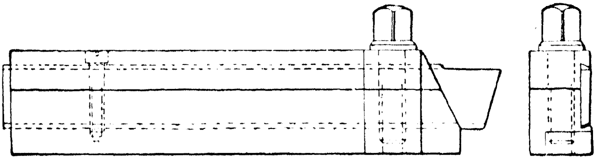


Fig. 61.—Tool Holder with Wedging Action

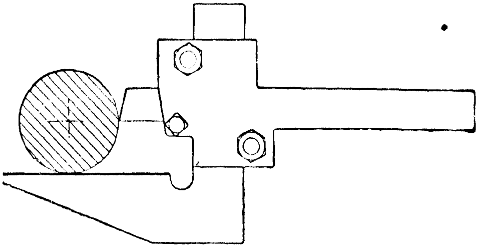


Fig. 62.—Burnerd Tool Holder

CHAPTER III

Taper Turning

The reader will find in Chapter VIII of the companion handbook details of taper-turning attachments for small lathes, and no special mention or repetition of that information is therefore necessary here. The method of turning a taper depends on its length, and also on the angle. A very short distance, such as a bevelled edge or chamber or a bevelled collar, is easily produced by means of a straight tool edge suitably presented, the knife tool usually being most convenient. The roughing out can be done with a narrow-pointed tool, working the handles of the slide-rest to move the point approximately to the desired slope.

The alternative arrangement for producing short tapers consists in swivelling the slide-rest top so as to traverse the tool at the correct angle, reading this off on the base graduations, and if necessary making faint alterations in position if the taper is wanted to be very exact. To match a sample taper, a pointer, or better still an indicator, is clamped in the rest, and the latter moved up and down until the top has been adjusted properly. When a hole has to be bored taper to fit the piece, the safest plan, when practicable, is to leave the rest swivelled, and so do the boring precisely the same. If such a proceeding does not happen to be convenient, careful note should be taken of the graduation marks on the base for re-setting.

Tapers that are too long for the length of movement of the top slide are dealt with either by a taper attachment or by setting over the tailstock to half the amount of taper. The first-named device, which is an extra fitting to the lathe, comprises brackets at the rear of the bed, holding a slide which may be adjusted to the necessary angle of taper. A block moving on the slide is connected by a link to the cross-slide, and pulls the latter (which is freed from its feed screw) as the saddle moves along. Short or long tapers can be done in this manner, leaving the tailstock still set centrally for intervals of parallel turning or facing off.

In the cross-setting method the tailstock is drawn across on its base by means of the setting-over screws until the work stands at the correct angle (Fig. 63), the incorrect method being shown by Fig. 64.

This method only happens to be of service when the work can be mounted between centres, whereas the two other devices above mentioned are applicable also to pieces held in the chuck alone. Of course, mandrel work comes within the scope of the between-centres method, articles such as bushings being turned taper thus (refer to the special chapter detailing mandrels in "The Simple Lathe and Its Accessories"). In order to obtain accurate tapers, the tool point must be at the exact height of centres each time; placing it above or below has the effect of changing the degree of taper. Another matter of interest is the result obtained by changing the axis of the work on the centres; throwing over as represented by Fig. 63 obviously alters the relation of the centre and countersink and leads to a certain amount of deformation at the head end, and of change by wear at the running or tailstock end. What such changes mean depends on the relative softness of the material, the pressure and duration of cutting, and the inter-relation of other parallel cuts. The axis of the piece cannot remain unchanged if much pressure and wear goes on. Therefore a standard mandrel, for example, ought not to be utilised for turning tapered bushings on, but a temporary one should be employed.

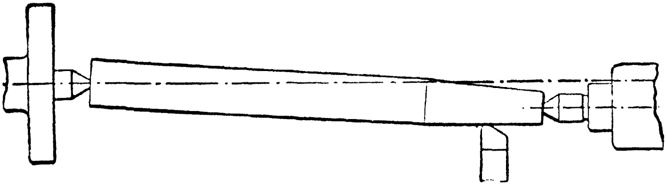


Fig. 63.—Diagram Showing Tailstock Set Over for Taper Turning

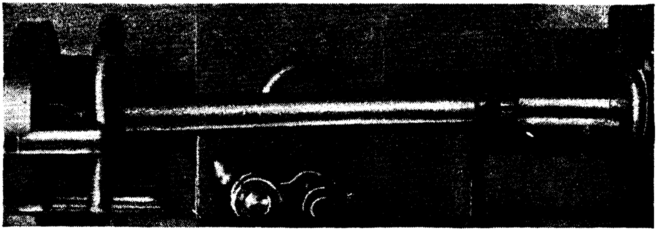


Fig. 64.—Incorrect Position of Work in Taper Turning

It is not generally recognised that setting over the loose headstock for taper turning has a deterrent effect on the preservation of accurate conditions. But if this operation is regarded in the light of a constantly changing axis revolving about an immovable one, as shown, again slightly exaggerated, by Fig. 65, there will undoubtedly be a better understanding and a clearer conception of wherein lies the fault of the scheme. At each revolution of the work the point of the centre describes a circle round the base of the conical hole, while against the outer edge of the latter the centre bears forcibly, according to the amount of end thrust exerted on it, in an opposite direction.

Suggested remedies are shown by the examples Figs. 66 and 67. Both of these, it may be said, however, are more applicable for use with heavy work and where the desired eccentricity of movement is rather great. This form of centre (Fig. 66) has a spherical end fitting into a semi-spherical centre hole in the work. Accuracy of fit is a *sine qua non* in the case, and if this is assured, as it may be if the centre hole is a perfect hemisphere machined out by means of a specially formed rose-bit, any desired setting over of the headstock may be accomplished with safety, and with no risk of centre wear destroying axial alignment.

The example shown by Fig. 67 has been most successfully used where the setting over has been abnormal. In this case the work centre should either be case-hardened or—and this was adopted in the writer's case—a hardened steel bush sunk into the end of the work, mandrel or arbor, into which fits the steel ball.

Figs. 68 and 69 show two useful forms of centres, the first being a particularly convenient form when it is desired to end face work close down to the centres. The second is a form of centre more applicable to universal milling operations. Its shape permits work of comparatively small diameter being slotted or milled to a depth almost reaching its axial centre.

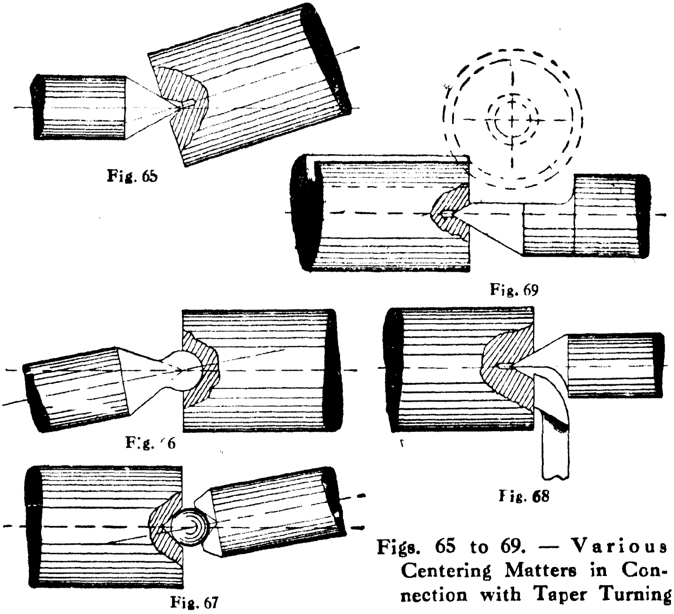


Fig. 65

Fig. 69

Fig. 66

Fig. 68

Fig. 67

Figs. 65 to 69. — Various Centering Matters in Connection with Taper Turning

If an accurate taper is required, it is advisable to test the taper with a piece of cigarette paper between the tool point and the work. The manner of testing is as follows :—The tool is fed up against the taper bar at the tailstock end and the piece of thin paper placed between the tool point and the bar. Without drawing the tool away from the work, the saddle is moved longitudinally until the tool is opposite the large end If the tissue paper fits here in the same manner as it did at the small or tailstock end, the tailstock is set over correctly. During this testing, no carrier has been placed on the bar, and it must be remembered that the tool point should be placed exactly on a line with the centre of the work as shown by Fig. 70.

The method of turning a short taper by means of the compound slide-rest is shown by Fig. 71. The tool post is swivelled round on its base sufficiently to produce the desired taper; in other words, the slope on the front of the tool post, in relation to the axis of the work, should exactly equal the desired taper.

Taper Turning with the Lathe Reversed.— It is obvious that an object chucked in a lathe without the use of the back centre could be equally well turned by applying the tool to the far side of it and running the lathe backwards.

In the great majority of cases, however, such reverse procedure would have no advantage, and as it is open to the very serious objection that the pressure of the cut then tends to unscrew the chuck from the lathe nose, it is seldom adopted. Nevertheless, there is one case in which it is to be strongly recommended, namely, when it is desired to turn a male and female taper exactly to agree with each other.

In the ordinary way, either the headstock or the top table of the slide-rest is set over the required number of degrees so that the female taper can be turned with an inside tool, and when the male taper is to be turned, the headstock or slide-rest is unclamped and refixed at the same number of degrees in the other direction, an outside tool being substituted for the inside one. By this method the chance of the two tapers being of precisely the same angle is really remote. The least inaccuracy of graduation of the swivelling part, or of the reading of the graduations, or the least shake in the pivot, etc., will cause the taper setting to differ. So, after turning the female taper in the cock-body, finishing with a high-speed light cut, chuck the plug in place of the body and finish that in the same way.

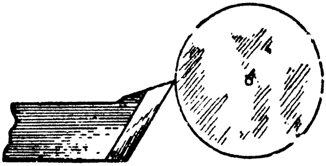


Fig. 70 —Position of Tool in Relation to Centre for Taper Turning

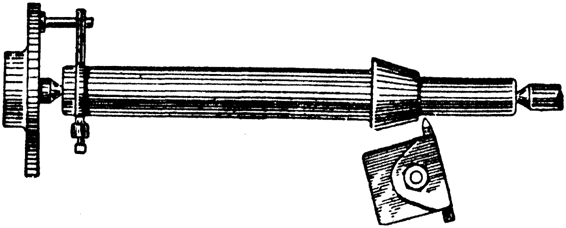


Fig. 71.—Turning Short Taper by means of Slide-rest

CHAPTER IV

Turning Scallops, Ovals, Curves, Etc.

A LATHE, whilst primarily intended to cut articles to a circular cross section, may be adapted to turn any geometrical cross sectional shape, whether regular or irregular.

Turning Ellipses. — Figs. 72 and 73 show an attachment easily made and fitted to any lathe for the purpose of turning a section tapering from round to oval, a section often desirable in making ornaments and other fancy articles. The change in section is, moreover, quite a symmetrical one and pleasing to handle. The ring A (Fig. 72) is elliptical, the difference in diameter being equal to the difference in diameter of the ellipse it is desired to turn. The arm B is provided with a roller C, held tightly against the ring by means of the spring D. The shaft E (Fig. 73) is secured to the lever B at one end, the other being supported by the upright piece F. Two rollers G are secured to the cross-slide on each side of the shaft E, and work the feed of the cutting tool as the work revolves. When the carriage is disposed at the left end of E nearly all of the motion on the roller C is carried to the cutting tool, while at the right-hand end of its travel the tool will have no motion, and that portion therefore will be round.

Turning Scalloped Circumference.—Hand-wheels and similar machine parts often have their periphery serrated or scalloped, so that a better grip on them may be obtained (*see* Fig. 74). The ordinary method is to mill them, afterwards cleaning up to a smooth hand-grip with a file. The whole operation may easily be done in the lathe by means of the tool arrangement shown by Fig. 75.

The tool shown by Fig. 76 is made from cast steel to the diameter of the required serrated circumference.

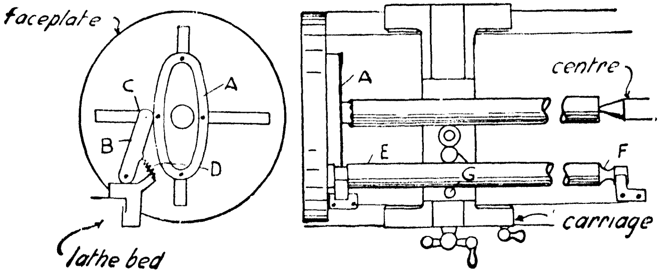


Fig. 72 Fig. 73

Figs. 72 and 73.—Attachment for Turning Ellipses

The roller (Fig. 77) is of tool steel, and of a diameter to suit the scallops in the work to be turned. Remove the feed screw from the cross-head of the lathe, and fix a strong spring from the cross-head to the carriage as shown. Also rig up the double tool post, shown in Fig. 75, on the cross of the lathe carriage. Now mount the work on the mandrel of the forming tool and place between centres, bringing the poppet centre hard up. Place the roller in the tool post, as shown at B (Fig. 75), and secure a lathe tool in the opposite tool post C. Next start the lathe, and the roller, as shown by

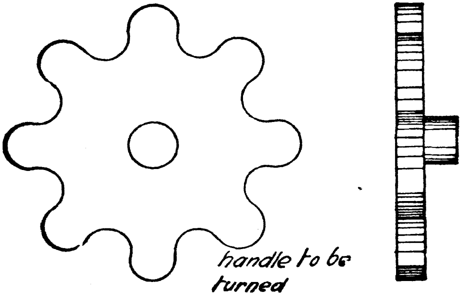


Fig. 74.—Scalloped Wheel

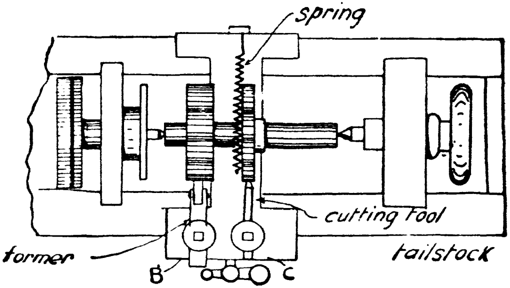


Fig. 75.—Tool Lay-out for Turning Scalloped Wheel

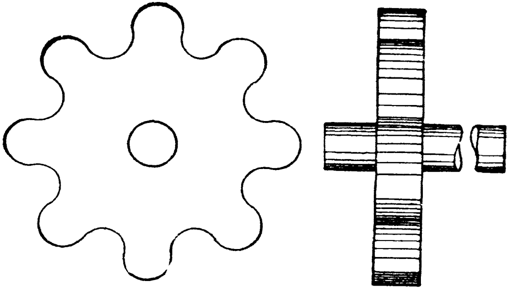


Fig. 76.—Scalloped Former

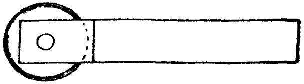


Fig. 77.—Roller for Scalloped Former

Fig. 75, will roll over the formed scallops and consequently feed the lathe tool into the work. This apparatus can be used for a variety of other work, such as polygons, cams, eccentrics, triangles, spokes, etc.

Turning a Hexagon, Octagon, etc.—For turning hexagons, octagons, etc., it is best to use a former in the chuck made as an exact model of the required work. The slide-rest is freed from its feed screw, and is pulled over against the copy plate by a heavy weight. A roller makes contact with the plate, carrying the tool with it, and therefore making the work a counterpart of the former-plate, that is, hexagon, octagon, as the case may be.

Turning Curves and other formed Profiles.—Long curves in the regular workshops are usually turned with the help of attachments, constructed on the same lines as the taper attachment described previously (*see* also Chapter VIII. of "The Simple Lathe and Its Accessories"), but with a suitably curved former to coerce the cross-slide to the required profile. Failing this provision, the curve must be produced by careful manipulation of the cross-slide handle as the saddle is moved along by hand or perhaps by automatic feed. The mode of dealing with a long curve, such as the outline of a bellied connecting-rod, depends on the quantity of material that has to come off. If it is somewhat excessive, a neat way of getting the outline with the minimum of trouble is to set in a parting-tool at various localities along the surface, gauging its depth of penetration to leave the size a trifle over the diameter at each spot. This method provides a series of data points, enabling the roughing down to be done with confidence from step to step, judging the curve with the eye, and finally testing with a template. Careful finishing is essential to secure a smooth and even surface, and the blending is done with a smooth file, completing the finish with emery-cloth.

Knobs and similar curved profiles may easily be formed by operating the cross-slide and horizontal traverse handles of the slide-rest (*see* Fig. 78).

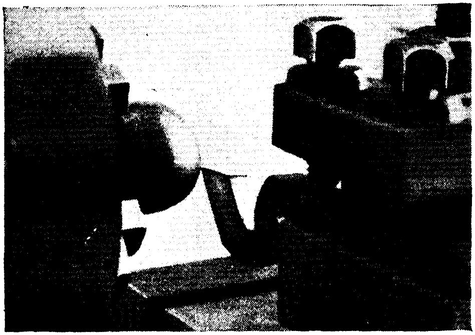


Fig. 78.—Forming Round Knob by Simultaneously Operating both Handles of Slide-rest

Short curves and those of small radius can be more readily produced. When sufficient work of the nature warrants the expense, a ball-turning rest is useful for moving a tool to exact profile, the rest being constructed with a rotary motion, actuated by worm and wheel. The alternative lies in making form tools, forged and shaped to the curve—internal or external—and applied after a preliminary roughing-down operation. Even though the quantity of metal to be removed is small, the advantage of roughing off with a point tool is the elimination of the surface scale, which dulls and damages the form tool quickly, and moreover prevents it from obtaining an easy and free-cutting start.

Tools for small inside and outside radii (Fig. 79) are usually made to standard curves and kept unaltered. If other radii are required, it pays to use holders, which may be made of the form shown by Fig. 80, suitable for cutting to right or left hand. The profile of the cutters does not change by the sharpening done on the top surfaces. Circular-form tools afford a strong shape, which may be sharpened for a very long period before it is necessary to discard the cutter. The adoption of a bolt fastening, as shown by Fig. 81, permits of laying the cutter on either flank of the holder, as may be required according to circumstances.

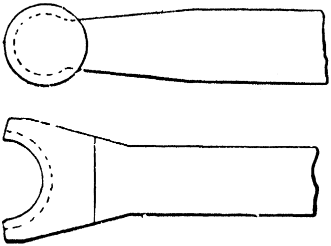


Fig. 79.—Form Tools for Internal and External Radii

Relieving or backing off in the lathe has been sufficiently treated in Chapter VIII. of " The Simple Lathe and Its Accessories " to need no special reference here. It must be understood that the attachments and arrangements shown in this chapter are capable of adaptation to other work.

Planing in the Lathe.—In small workshops where neither planing nor milling machines are available the practice of cutting keyways in shafts involves much time and labour. It may, however, be effectively done in the following manner:

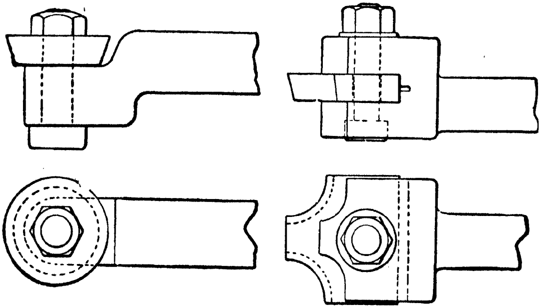


Fig. 80.—Radius Tool Holders

Having marked off the keyway on the shaft, it will be necessary to drill two flat bottom holes at each end, the diameter and depth being the same as the width and depth of the keyway required; this will give clearance for the tool. The shaft is now held between the lathe centres, not too tight, and is prevented from turning by means of a carrier and blocks of wood. A parting-off tool, ground exactly to the width of the keyway, is held in the slide-rest on its side, and in line with the lathe centres. If the saddle is run along by hand, with the tool touching the shaft, it will be seen that a good shaving is taken off each time.

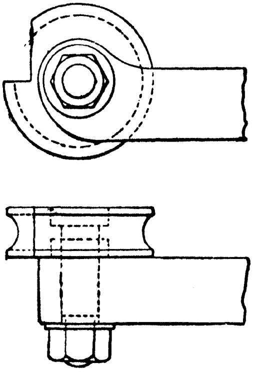


Fig. 81.—Circular Form Tool

CHAPTER V

Double Tool and Time-saving Methods

THE employment of more than one tool at once in the lathe often affords a means of saving time and ensuring accurate results, as compared with the separate use of tools. Two principal advantages are gained; one that the relative setting of two or more tools enables duplicate pieces to be turned exactly alike, and the other that time is economised by the simultaneous operation. The amateur cannot practise this method to any great extent, because, as a rule, his work does not include very much repetition of similar shapes, so that often for a single piece the time of adjusting the tools would occupy as long as

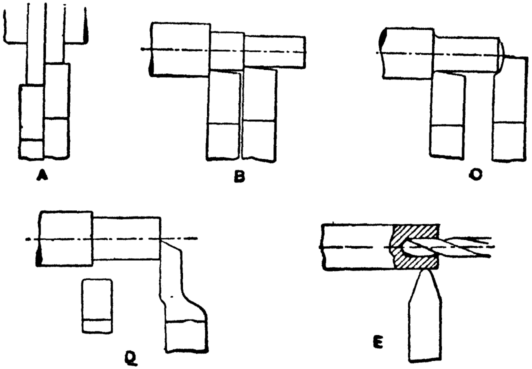


Fig. 82.—Various Examples of the Use of Double Tools

running down with two independent cuts. This is not always the case, however, and the following hints will be of assistance in following the double method, the illustrations being typical only of a great number which might be drawn of various types of work and conditions of tool application.

Shouldering and Chamfering with Double Tools.—In Fig. 82, A, B, and C illustrate common instances of shouldering and chamfering, with or without lateral traverse. At A the tools are fed straight in, and turn the two diameters in a fixed relation to one another. The shoulders often occur on brasswork and on some kinds of spindles. At B a side traverse has to be given to turn down the two diameters, and at C the chamfering tool at the end comes into operation when the turning tool has finished up to the shoulder, thus ensuring accurate length from end to shoulder. An alternative is seen at D, where a knife tool is shown finishing off the end of a pin after the body has been turned with the other tool. The two tools occupy the fixed relations seen, and when the turning tool is in operation, the knife tool stands away to the right clear of the work. E represents a double operation, which is often feasible during turning, when a drill can be fed up simultaneously from the tailstock; or, if this is not convenient, the drill can be held ready for use, and brought into action after turning.

Surfacing with Double Tools.—Two examples of double tools set to face surfaces in different planes are given in Fig. 83, both ensuring accurate distances from one face to the other. One of the most generally useful applications for two tools is that of facing down the two sides of a wide or a narrow piece, such as a pulley or distance piece, or a washer or disc. In the latter case the additional advantage is gained that the tools balance one another and the disc does not spring laterally. The choice of tools must depend on those available; perhaps a solid tool and a tool holder may have to be utilised together. Three alternatives are illustrated in Fig. 84, comprising ordinary turning tools inclined towards each other, right and left-hand knife tools, and parting-tools. The last named are liable to spring apart, and are not so reliable except for fine finishing cuts. Another handy use for parting-tools is when a series of grooves has to be made at uniform widths apart, or a number of rings or ferrules has to be cut off from the tube (*see* Fig. 85). Exact cutting to width is rendered easy without troubling to measure.

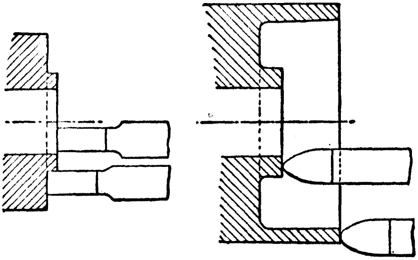


Fig. 83.—Two Tools in Use for Facing

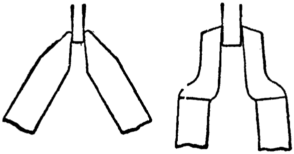


Fig. 84.—Double-facing the Sides of Work

Other Double-tool Methods.—The opportunities for using double tools in boring are not so frequent, because the work is generally plainer and simpler than turning. Sometimes it is practicable to use two boring tools set to follow for shouldering out a bore, or to set the following tool to chamfer or bell-mouth the hole. Or a boring tool can be fed in simultaneously with a turning tool operating outside (*see* Fig. 86), thus balancing the cutting forces and saving time. A small boring-tool holder held in the tailstock affords the means of leaving the slide-rest free for any class of manipulation, and the boring tool is fed in at the same time turning is done, or is reserved for action afterwards. A holder is shown in Fig. 87, taking a cutter inclined to reach to the bottom of a hole. Instead of boring, a bell-mouthing or a chamfering cutter can be employed as at A, to save the time and trouble of changing a tool already gripped on the slide-rest. Simultaneous double chamfering of exterior surfaces is useful in the case of collars and nuts, etc., the tools being disposed as in Fig. 88, when the straightforward types are used, or not inclined so much if bent knife tools are available.

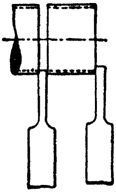


Fig. 85

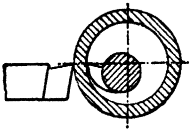


Fig. 86

Fig. 85.—Method of Parting-off Uniform Lengths of Tubing

Fig. 86.—Simultaneous Boring and Turning

When a lathe rest has the four studs and two clamping plates for holding down tools, there is no difficulty about gripping two or more tools set at a considerable distance apart. But with the circular kind of holder under which the tool is clamped with two screws, the case of two widespread tool shanks must be dealt with by laying a narrow tool or strip flatwise to span over them, and let the screws press on the top strip which thus bridges them. The adjustment of the cutting edges to the exact distance apart is not a difficult matter, being accomplished most conveniently by gentle tapping with a hammer. Tools set close alongside each other may have to be adjusted by forcing a wedge, such as a screwdriver or a chisel, between them at the front or the back, depending on whether the edges have to be separated or contracted

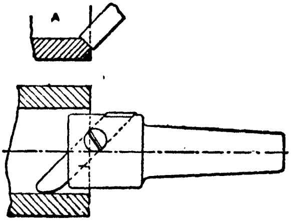


Fig. 87.—Tool Holder to Operate from Tailstock

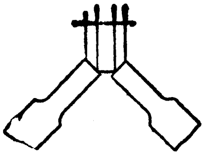


Fig. 88. — Tools Set for Simultaneous Chamfering

Another handy tool for saving time is illustrated in two forms by Fig. 89, the principle chiefly consisting of a tool brought down over the nose of another one which is not moved. At A a knurl is seen pinned into a small holder that is clipped on to the sides of the turning tool by tightening the nut of the bolt. The bolt head is sunk into the plate in order that it may be approached close up to the chuck. Both plates are prevented from swivelling by a dowel pin driven through as illustrated, and their faces should be recessed in the manner visible in the side view of one plate. so as to make sure of a secure hold on the sides of holder and tool. At B the time of placing and removing the holder is done away with; a shank is laid on top of the tool, and hinged to it there is a swing piece carrying a circular cut-off tool. The piece is swung down to perform the cutting off and thrown up afterwards, leaving the turning tool free. A bevel ground on the left-hand side of the swing piece permits the cutting-off blade to approach very closely to the chuck jaws.

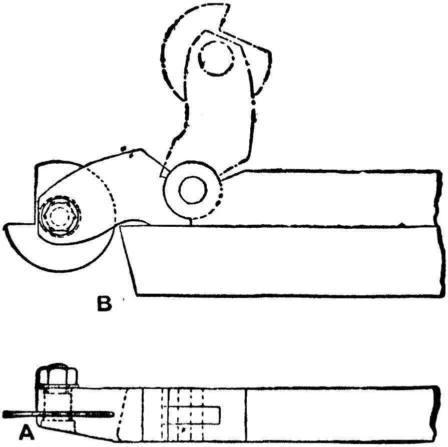


Fig. 89.—Another Form of Combination Tool

Device for Avoiding the Unsetting of Lathe Tools. —A number of parts of similar shape and dimensions, when undertaken in an ordinary lathe, call for a continuous resetting of tools, although even when not on repetition work to have tools set ready for use and only requiring to be brought into position, makes the work much more pleasant. Figs. 90 to 92 show two inexpensive methods of doing this.

Taking Fig. 90 first, it consists of a casting or forging, though of course it can be built up, and as shown in the three views (Fig. 91) has a hole bored and reamed a push fit on the sleeve of the tailstock. The hole is then slotted as shown, say about $\frac{1}{8}$ in. wide At right angles to this slot (*see* B, Fig. 91) are drilled two holes, one clearing-size on one side of the slot and the other tapping-size. Into these are screwed the bolts which hold the tool holder to the sleeve of the tailstock.

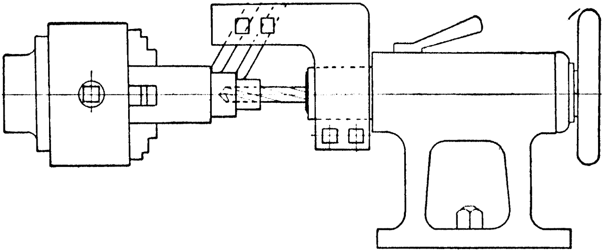


Fig. 90.—Simultaneous Turning and Drilling from Tailstock

The holes at C (Fig. 91), for the actual turning tools, are drilled at an angle, so as to enable the tool nose to be in advance of the end of the tool holder. As many tools as wanted can be fitted, though it must be remembered that the longer the dimension X the greater the leverage and consequent strain on the holder and tailstock. The same applies to dimension Z, which, if too great, means using longer tools, which would "spring and chatter." To keep this dimension as small as possible, a good idea would be to have several of these holders arranged for use on work of different diameters.

If in the parts being made there is a hole to be drilled concentric with the outside, it is very convenient to sweat the drill into a piece of steel or brass previously turned to the same taper as the tailstock sleeve, and use at the same time as turning by means of the bracket just described (*see* Fig. 90). The bracket tooled up thus enables the cross slide to be kept set with any other tool, in particular a screw-cutting or recessing tool.

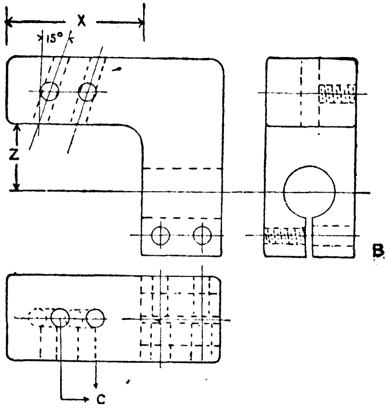


Fig. 91.—Construction of Bracket shown by Fig. 90

Fig. 92 shows a useful device which has grown in popularity in many shops, and is supplied by many machine-tool builders. It is shown in a simplified form of the usual pattern, and can be easily made, the only difference being that the kind usually bought possesses a base plate with indexing mechanism, but is unfortunate in not being adaptable to various lathes. In the one here shown no dimensions are given, as the height of lathe centres vary, as also does the design of cross slides on which the holder must rest. Therefore the application of the idea only is shown, and it is left to the worker to use up any spare material he may have by him, and generally make it to suit himself. In fact, there is no reason why, in special circumstances, it should not be made of hexagon form, thus holding six tools.

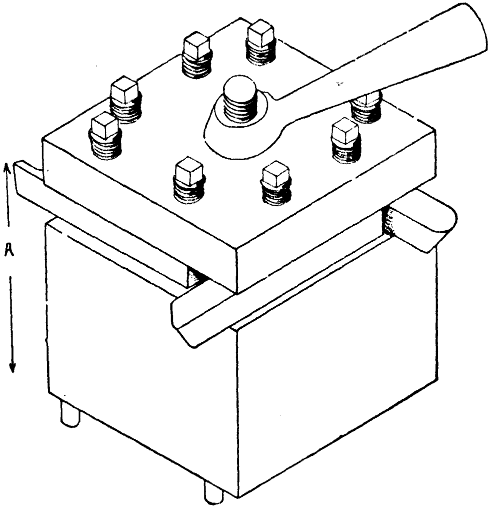


Fig. 92.—Tool-box for Holding Four Tools

The style illustrated consists of a cast-iron block with slots for the tools, and this will decide the height of the slot to the base, the dimension A being the height from the top of the slide to the lathe centre.

The four pegs at the base serve to index the holder at the four positions. They should be of tool steel hardened and tempered, and arranged in four positions to suit the form of slide-rest at hand. The eight set-screws are for holding the tools in position.

CHAPTER VI

Drilling and Boring in the Lathe

Methods of Drilling and Boring.—It is necessary to first consider the various methods of drilling and boring with regard to different classes of work. The tools, devices and tool holders used in boring are very fully discussed in Chapter XI. of the present handbook.

Drilling and boring in the lathe covers the application of a drill in a chuck on the spindle; drilling pieces which are fed up by the tailstock or by the saddle, or, vice versa, the running of a piece in the chuck and the pushing up of the drill from the tailstock or the saddle; reaming by both methods; boring by means of a tool projected from the slide-rest, with the job rotated by the spindle; boring with a bar between centres, with the article fastened to and fed by the saddle.

The difference usually made in speaking of these terms, that of originating a hole from solid metal (drilling), and of enlarging one already made (boring), is not a good definition because drills can be employed to enlarge holes up to quite large diameters, and some tools that are called drills or boring bits will originate holes from the solid. The lathe offers facilities for making holes either with or without a prepared aperture, because if the article is swung in the chuck, an accurate start can be effected by running in a tool to a short distance, so obtaining a concentric aperture and guidance for the drill. This is always advisable in the case of rough holes, for the mouth is thereby trued, and the irregularity exercises little or no influence on the following drill, and, therefore, greater likelihood occurs of securing a concentric and true hole. In theory it ought to be easy to obtain a true hole after such a start by feeding in a drill of the required size, but the faults in cored or forged holes are numerous, chief of which are the lack of roundness and straightness, and also the existence of blow-holes, cold shots, cavities, scale, and soft and hard portions at different localities. Such defects deflect the tool, therefore two or more passes through with a single-pointed boring tool operated from the slide-rest may be necessary to gradually eliminate the undesirable effects, following which the sizing drill or reamer completes the operation.

Often the method is reversed, that is, the rough drilling or enlarging is done first, and the boring tool then skims through once or twice for corrective purposes before finishing. The choice of methods often depends on the size or exact degree of fit that is wanted. A standard-sized hole may be put through with a regular drill or reamer, especially for quantity production, whereas a slight variation above or below standard will necessitate the application of a single-point boring tool The alternative to this lies in the use of a boring tool or bar, or a reamer with adjustable cutters or blades, by which sizing may be repeated as often as desired.

Drilling from Headstock or from Tailstock.—The main points which decide whether a drill shall be driven from the headstock or fed up by the tailstock are the shape of the piece and the question whether concentricity with the exterior is important. The average kind of drilling, such as is commonly done under an ordinary drill press, can be dealt with by feeding up the piece with a drilling-plate on the tailstock-spindle nose. But articles such as rods, washers, discs, and other circular parts are generally better gripped in the chuck, and then the drill can readily be brought to the centre after a preliminary centering operation. The majority of objects of this sort are, moreover, more easily gripped in the chuck than by any appliance fitted to the drilling-plate. Of course a chuck may be fitted to a shank in the tailstock barrel, but this usually offers no advantages over the alternative method just specified.

Centrifugal force plays an important part in the matter of concentric drilling, for there is a greater chance of the drill seeking and keeping to the central axis when the work is rotated.

Driving Drills.—It is never advisable to drive a drill from the taper hole in the spindle, because this hole should be kept as true and undamaged as possible for the function of running the centre truly. A drill chuck should always be used; the regular jaw chucks may be wanted for large and heavy drills, but owing to the projection of the jaws they are awkward in use. A small self-centering chuck, if used much for drilling, is preferably fitted with the special drill or rod jaws, which possess smooth sloped edges that do not catch in the hands or clothes, and are less in the way. The regular drill chucks provide a small and compact shape more suitable for drills than the usual self-centering chucks with inside and outside jaws. A drill chuck is therefore a good investment and a time-saver, and it is far better to buy a modern one with reasonable adjustment of jaws than to make use of one of the old-fashioned type with pinching screw, and adapters. This latter is a clumsy tool, the set-screw sticks out in an awkward and dangerous fashion, and the drill shanks and adapters become battered and deformed and loose, so that the drill cannot be made to run true. An example of this older design of chuck is seen in Fig. 93 with one size of adapter in place and the set-screw reaching to the flat on the drill shank, so as to grip this and the adapter simultaneously. A simple chuck, suitable for one diameter of shank, is shown by Fig. 94; the drill ends in a flat which catches on the ledge cut behind the hole and is thereby driven positively. For those who happen to use taper square-shank drills the taper-hole chuck (Fig. 95) is required.

Concentric Drill Chucks.—These are roughly divisible into the types actuated by a knurled ring and threads and those worked by a right and left screw turned by a key. The latter are very powerful, and provide a hard grip through interlocking jaws with several "bites," but the parallelism of the body is not quite so convenient for seeing and manipulating the small drills, countersinks, counterbores and other tools. Fig. 96 shows a typical chuck of the knurled-

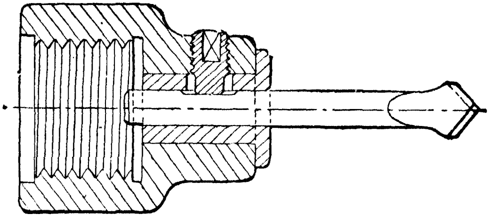


Fig. 93.—Old Adapter-type Chuck

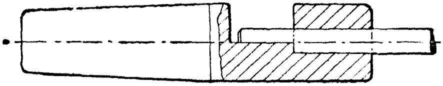


Fig. 94.—Drill Chuck that Drives by Flat on End of Drill

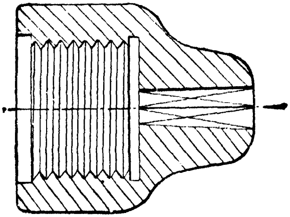


Fig. 95.—Chuck for Taper Square-shank Drills

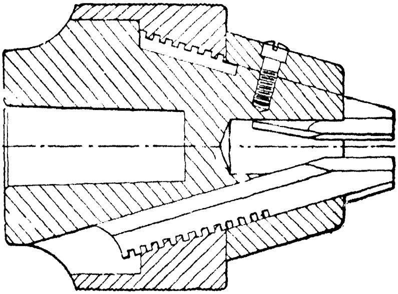


Fig. 96.—Knurled-ring and Thread Chuck

ring-and-thread pattern, the threads within the ring moving the three jaws simultaneously. Holes drilled in the ring permit the use of a tommy or hooked spanner for extra tightening, or for loosening when

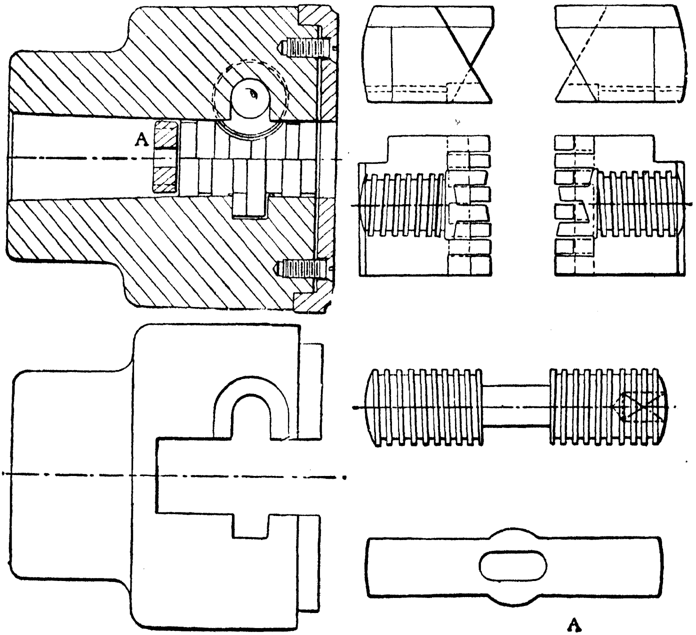


Fig. 97.—Jones and Shipman Screw Chuck with Interlocked Jaws

the clasp of the hand is insufficient to effect this operation. The geared chucks are more recent improvements on the foregoing type, the improvement consisting of a ring of teeth cut on the knurled sleeve, with a bevel gear on a stem with a cross handle. This is inserted in one of the holes around the nose, and the ring is thereby turned with a powerful effort, with no necessity to hold the spindle from revolving as is necessary in the case of the type shown by Fig. 96 The Jones and Shipman screw design with interlocked jaws is shown in Fig. 97. The strong square threaded screw draws the jaws together or separates them, and the interlocking of the bites allows of a suitable range of grip from the smallest diameters to the largest sizes within the capacity of the chuck. To provide a positive drive on drills that happen to have tangs, a floating tempered steel plate A is laid in the end above the jaws, and saves the chewing up of the shank in the endeavour to get a tight hold during heavy drilling.

Other Drill Chucks.—Other drill chucks sometimes used in lathes comprise the spring type (similar in principle or shape to the spring collet chucks mentioned in Chapter IV. of " The Simple Lathe and its Accessories ") and also the brace-bit chucks, which are constructed with two pivoted jaws that are pulled together by a coned sleeve. These latter cannot be depended on to hold so accurately as the sliding-jaw chucks.

Feeding the Work.—For the usual run of flat shapes a drilling-plate is utilised, held either by a taper shank, or by a hub encircling the barrel, these being shown in Fig. 98. The first method is open to the objection that the centre hole is not improved by its use; and that the end pressure jams the shank in hard. A moderate diameter of pad such as is shown answers for the general run of work. Larger and smaller sizes are, however, often found desirable. The

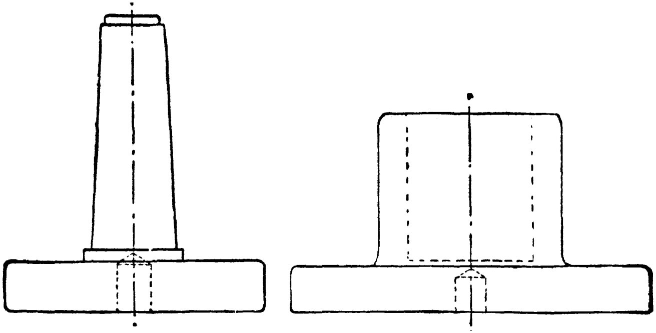


Fig. 98.—Forms of Tailstock Drilling-plates

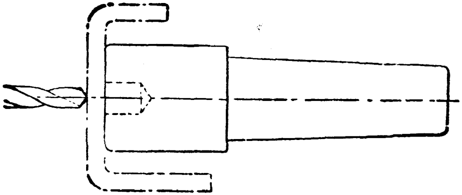


Fig. 99

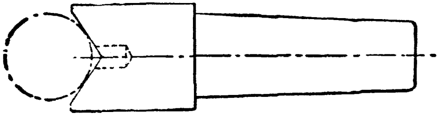


Fig. 100

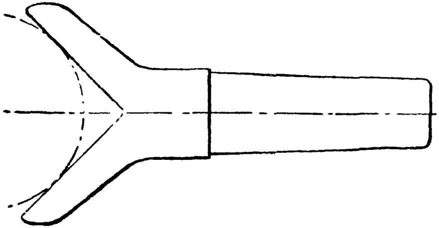


Fig. 101

Figs. 99 to 101.—Other Forms of Work Supports for Drilling larger ones allow of supporting bulky or awkward or spread shapes. The small size (Fig. 99) is chiefly applicable to sustain narrow pieces like that shown dotted. A valuable class of pad is the **V**-centre (Fig. 100) or the large size (Fig. 101), employed to support round shapes without permitting them to roll.

The swivel **V**-centre is a modified form of Fig. 100, with a loose head that swivels to any convenient angle for the hold of the work as it lies in the **V**.

Two matters which concern this subject are the method of holding small pieces against the rotational effect or torque of the drill, and the means of regulating the depth of penetration. With reference to the first-named matter, when a job is long enough to be held by the hand, or rested against the bed or slide-rest, the twisting effort of the drill may be easily resisted. But if the piece of metal is small, or of square or round outline, there is difficulty in stopping it from twirling. Sometimes a stop peg can be inserted in the drilling-pad, or a plate of metal be clamped in a suitable position against the side of the work. Another device is the tightening of one or two ordinary clamps on the face of the object. The faceplate can be employed for this purpose, to save having a large duplicate plate; in this event, it is only necessary to prepare a replica of the spindle nose, with a tapered extension to fit in the tailstock barrel, or a bored hub to fit on the exterior of the latter. This arrangement has the advantage also that the dog chuck can be put on the replica and fed up by the handwheel. Pieces of similar shape can be held successively in the same position for drilling.

The control of the depth of the hole is essential when dead-ended holes are drilled. There are several ways of exercising this control, either by visual or by positive stop devices. Marking graduations on the tailstock barrel is a simple method, but not very convenient in use because one has to carefully watch the lines as they emerge from the tailstock casing. Another method consists of applying a rule to the distance between the back face of the drilling-pad or plate, and the front edge of the tailstock casing, the

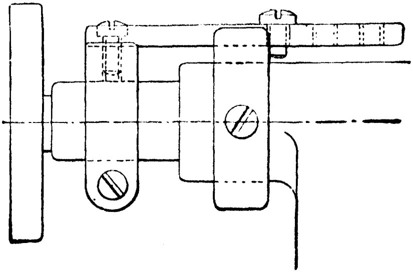


Fig. 102.—Device to Limit Depth of Hole

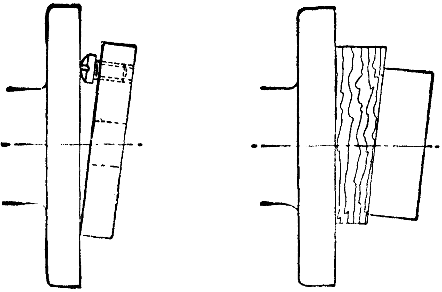


Fig. 103

Fig. 104

Figs. 103 and 104.—Devices for Drilling Holes at an Angle

feeding being stopped when a definite distance has been traversed. The most efficient idea makes use of a positive stop, two forms of which may be instanced here. Fig. 102 embodies a collar clamped to the barrel, and holding a flat strip; this slides through a slot in a collar pinched to the tailstock hub, which thereby operates as a positive stop by the resistance of the screw, set into whichever tapped hole happens to suit the stroke. By clamping a tool or piece of bar in the slide-rest and letting it project out to encounter the face of the drill-pad, a much simpler device is formed, the position of the saddle along the bed being, of course, adjusted to suit the depth at which it is required to arrest the feed. A good method lies in making the chuck-jaws act as a stop collar, by projecting the drill from them only to the exact depth of the hole. The spaces between the jaws allow more freedom for chip passage than a continuous collar, and should any slip occur it is on the safe side, for the drill recedes and the holes are not so deep as intended, instead of being deeper, as when a collar slips back.

Drilling at an Angle.—The amount of drilling that is required to be done angularly in relation to the work faces is not large by comparison with the vast amount of ordinary right-angle drilling. Consequently when such angular drilling becomes necessary it is sufficient to cut a wedge of appropriate taper to pack the piece out to slope (Fig. 103), or to provide for a slight degree of adjustability as shown in Fig. 104, with a couple of screws adjusted as desired. Clamping the piece upon an angle plate, which is bolted to the drilling-plate, permits of angular adjustment in the horizontal plane, and enables the article to be swivelled round successively to put in several holes. The job can also be bolted to the saddle or the top of the slide-rest and set to position, or an angle-plate might be fixed to the saddle and swivelled tc present the work at the correct angle.

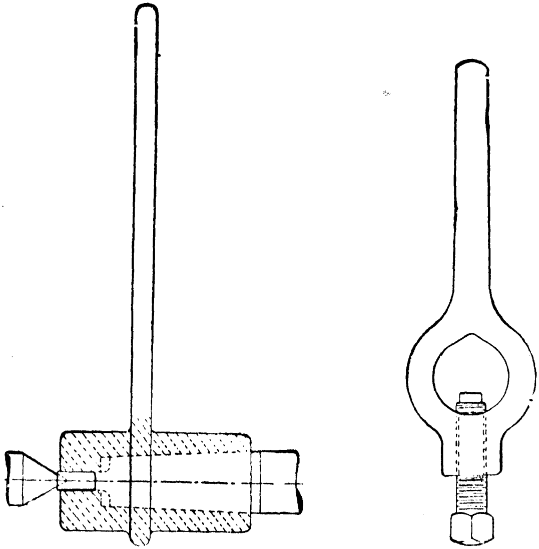


Fig. 105 Fig. 106

Figs. 105 and 106.—Carriers for Preventing Rotation of Drills when operated from Tailstock

Drilling from the Tailstock.—Heavy drilling from the tailstock is not effectively done by the chuck, for this can only be held frictionally with a taper shank. Therefore, while light drills and countersinks can be successfully held in a concentric chuck mounted on a taper shank slipped into the barrel, the heavy drills necessitate placing a carrier or a drill-holder with a long tail on the shank, the tail of the holder coming against any convenient abutment. The type of holder used depends on the shape of the shank. Taper shanks with tangs are used in conjunction with a socket, elaborated into a handle (Fig. 105), while a sort of heart carrier with elongated tail (Fig. 106) serves for various sizes of parallel shanks, either round or flattened. If drills or boring-bits are fashioned from flat stock a simple hook holder is employed, the end of a length of flat steel being turned round in the way represented by Fig. 107 to embrace the drill. When there is much boring to be done with flat bits, a usual device is that of disposing a slotted rest close up to the work, the drill sliding through the rest, and being at the same time steadied close to the work. The rest consists of a bar projected out from the slide-rest in the same manner as a tool, or formed with a stem to slip into the T-rest (Fig. 108).

Starting Drills into Work.—The neatest method of getting an accurate start centrally for a drill fed from the tailstock is to bring up a point tool from the rest and prepare a recess as the piece is run round by the chuck (Fig. 109); this offers facilities for subsequent correction of the recess after the drill has penetrated a brief distance and is found not to run true. When the piece rotates at a high speed it is frequently found that a drill may be started with perfect concentricity by the action of the work. Or, if there is a slight error, this can be rectified by a lateral pressure, as offered by the pressure of a bar of metal gripped in the rest and forced against the drill close to the point (Fig. 110). The preparation of a starting recess by means of a Slocomb drill worked from the tailstock is an excellent method, using a centering cup, or holding the drill in an ordinary chuck.

The Choice of Drills.—The choice of either a common flat drill, or a straight-fluted, or a twist-drill, of course, depends largely upon the class of material to be dealt with. The flat drill, if properly made, is handy for odd sizes not covered by the regular manufactured drills, being also convenient for finishing the bottoms of holes to special angles. The straight-fluted drills, which are preferred for brass and gunmetal and such-like soft materials, do not cut nearly so well as the twist-drill in wrought iron and steel, nor do the chips escape so freely. The only disadvantage of the twist-drill in lathe work is the running-through tendency, which makes the drill screw its way fiercely at the moment of breaking through the metal at the

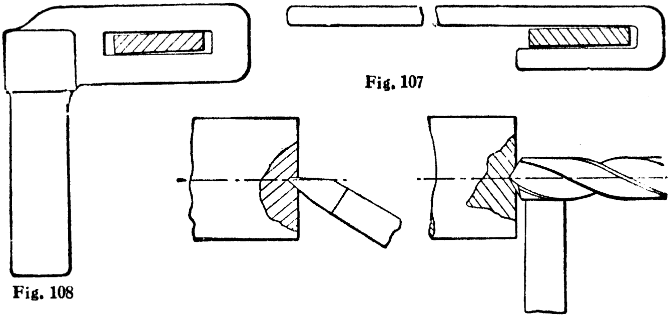


Fig. 107

Fig. 108

Fig. 109

Fig. 110

Figs. 107 and 108.—Catch-pins for Flat Drills

Figs. 109 and 110.—Preparing Start for Drill with Slide-rest Tool back of the work. Careful feeding is imperative, and the lathe should towards the end of the cut be slowed down, or even pulled round by hand until the body of the drill is safely through the hole.

Drills for Enlarging Purposes.—Twist-drills with three, or sometimes four, lips are quite suitable for enlarging holes, and they are used extensively in manufacturing operations, particularly in the " chucking " lathes that operate on castings and forgings with rough holes.

A flat drill with only two lips can, however, be made to open out very nicely, provided the " land " behind the lips is sufficient in amount to provide a good steadying effect against the walls of the hole. Such drills are ground as illustrated in Fig. 111, to cut only on the ends, which have the corners either formed to a radius, or chamfered off at an angle, as also shown in Fig. 111. If the piece is to be subsequently chucked upon a mandrel for turning and facing the exterior portions, and the concentricity of the hole is not therefore very particular, the drill can be started in without any kind of preparation. Should close approximation to concentricity be essential, a slide-rest tool must be passed in for a short distance, to carefully skim out a mouth very slightly less than the size of the drill, which will enable the latter to commence in a central position. The tail of the drill, being supported on the tailstock centre, is free at the cutting end to centre itself, and will therefore produce a fairly true hole. Exact sizing may be done with a second drill, taking a very fine cut through, or with a reamer. A cheap tool by comparison with the reamer is an expanding boring tool, with cutter expanded to the required dimension; this is done either by making it in halves or by splitting it partly through, both of which methods are seen in Fig. 112. Another reamer substitute for obtaining very smooth holes with only two cutting edges is shown in Figs. 113 and 114, where pads of wood are screwed on the sides of the drill, their curves making a fit in the hole and steadying the edges nicely. A similar action is produced by the rose reamers and the drills or reamers with round bodies of full diameter (refer to Figs. 115 and 116), both of which fill the hole as it is being opened up and give great smoothness to the walls.

Though the **D**-bit has only one cutting lip, the half-circle or so of body fits the hole and prevents the edge from retreating or vibrating. Some **D**-bits are made with removable cutters screwed on, but the solid type (Figs. 117 and 118) is easier to make, and is better suited for general work. The end of this tool is not suited for starting a hole truly; it is necessary to mouth out the hole for a short distance.

A generous supply of lubricant is required for successful working to keep the edge and work cool and also to wash out the chips; with deep holes a pump is required to force the oil or soapy water into the hole with ample volume and force. The question of lubricant has, however, been fully discussed in Chapter I.

Figs. 119 to 121 show an idea for preventing the rotation of the smaller sizes of straight-shank drills

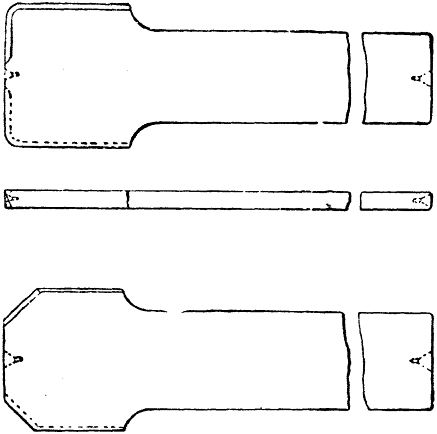


Fig. 111.—Drill for Enlarging Holes

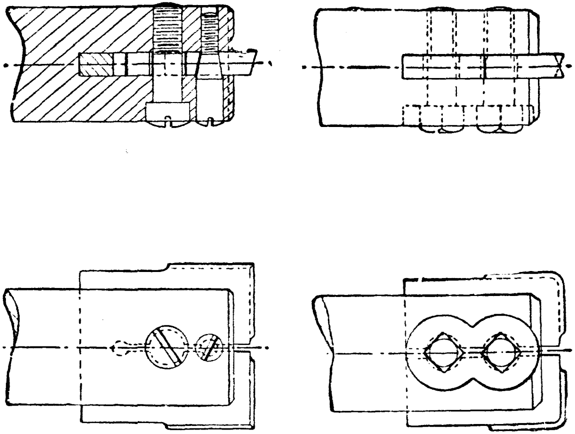


Fig. 112.—Forms of Expanding Boring Tools

which are fed up by the tailstock. The best way is to fit a small drill-chuck to a plug held by the tailstock barrel; but failing this, the device shown is a very good substitute. The fitting is cut out with a tapered square hole, and the ends of all the drill shanks, say from $\frac{1}{4}$-in.

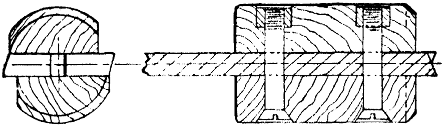


Fig. 113
Fig. 114

Figs. 113 and 114.—Wooden-pad Pilots for Flat Drill

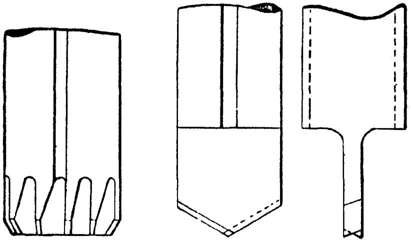


Fig. 115
Fig. 116

Figs. 115 and 116.—Rose Reamer and Drill Reamer

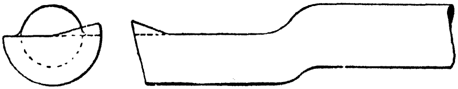


Fig. 117
Fig. 11

Figs. 117 and 118.—Solid Type of D-bit

down to $\frac{1}{16}$-in. diameter, are filed square and with a taper corresponding to that in the hole. Any size may then be pushed into the chuck, and will be held firmly, leaving both hands free.

A rig-up for feeding a drilling-pad by direct hand pressure, without using the tailstock screw and handwheel, is shown by Fig. 122. For fine drilling, the screw method is unnecessary. Precision lathes usually have a lever-feed tailstock, or an attachment of the same nature, so that it may rapidly be advanced or withdrawn. The fitting shown is for fine drills, which can be given sufficient pressure, the fingers being clasped round the pad A to push it and the work laid against its face. This pad is forced on to the taper nose of a rod B, turned and polished smoothly

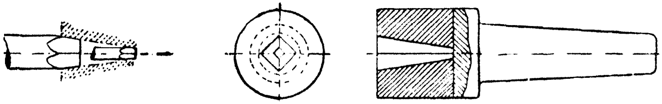


Fig. 119 Fig. 121 Fig. 120

Figs. 119 to 121.—Tailstock-barrel Drill-pad for Parallel-shank Drills

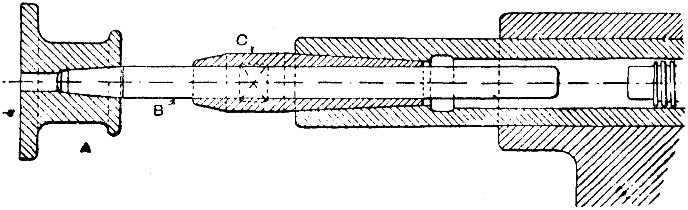


Fig. 122.—Sliding Rod for Hand-feed for Delicate Drilling

to slide without slack in the hollow plug C, which occupies the hole in the tailstock barrel otherwise taken by the ordinary centre. As will be noticed, the barrel is run out sufficiently to leave space between the end of the screw and the rod. A better way is to fit a small drill chuck on the nose of the rod, or keep a separate rod so fitted. A further alternative would be to make the hole in the pad of the shape given in Fig. 119.

There is a way of securing a true movement of a boring-bar independently of the work, which is often adopted when the preliminary hole in the object is of a sufficient capacity. The bar is continued at the end into a pilot extension of the same diameter or a little smaller, and it slides through a steady bush fitted either into the chuck or into the spindle hole (*see* Fig. 123). Such an arrangement gives concentric holes if used carefully, irrespective of whether the cored or punched hole runs true. There is no need to employ the slide-rest for starting purposes, and it is consequently available for holding a tool to perform other functions as fast as the boring of each piece is completed. These piloted bars are often used with multiple cutters—that is, a second cutter is fixed in at a suitable distance along to do a chamfering, or bell-mouthing, or facing process directly the boring cutter is through.

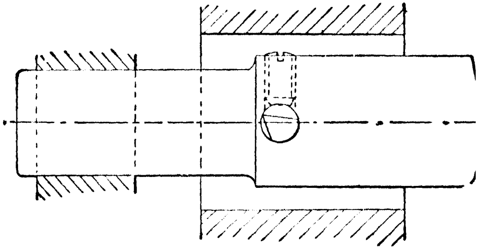


Fig. 123.—Boring-bar with Pilot End

Boring from the Slide-rest.—For all excepting long holes the slide-rest boring tool furnishes a convenient method of enlarging holes. The size can be readily altered as required, and subsidiary operations are easily effected by manipulating the slide-rest accordingly. A large choice of tools and of holders is available for this class of boring, some merely alternatives for the same kinds of cutting, others definite modifications for particular functions. An examination of the principal styles, with remarks on their advantages, may now be made.

Types of Slide-rest Boring Tools.—The principal feature of any boring tool is the facility with which its end operates, in regard to (1) the clearance, and (2) the corner finishing, when the hole does not go right through. The question of clearance is most marked in small holes, where the quick curve of the wall interferes with the tool unless this is ground well away. The end view (Fig. 124) illustrates the relation of wall and tool clearance, and is correct, and Fig. 125 incorrect, the latter not being ground away sufficiently. It is important to be careful of this detail, for the liability of a long projecting tool to spring renders free-cutting properties very necessary; any slight degree of rubbing easily leads to deflection, and the parallelism and concentricity of the hole will be impaired. In the case of small holes the cross-section of the tool must be diminished to give clearance, and in order to still retain stiffness as far as possible the major portion of the shank ought to be left to standard size. Many of the holders (discussed in Chapter XI. of this handbook, which also deals with cutters) for boring purposes are constructed to project the bar only as far as required to go to the depth of the hole, which plan offers an advantage over a bar that is tapered down

The shape of the point and its position in regard to the end must be considered according to whether the hole is bored right through, or stops at a blank end or a shoulder, or whether under-cutting has to be performed. A round nosed-tool is correct for through boring (A Fig. 166) and is suitable for either roughing or finishing, according to the degree of rounding on the edge and the rate of feed. The finest finish is, however, produced by a straight-edged tool (B Fig. 166) which will, moreover, run up to a shoulder. The diamond-point (C Fig. 166) is good for roughing, and is handy for occasional extra cuts such as chamfering at the ends, or touching off external corners without troubling to change the tool for another. For chamfering or facing down inside shoulders the inside edge of the tool has to be cleared off as at D (Fig. 166), a similar shape serving for narrow recesses, the tool being made of suitable width. Another shape of end which is handy for light cutting, such as in brass, gun-metal, aluminium, etc., extends into a rather fine point (E Fig. 166).

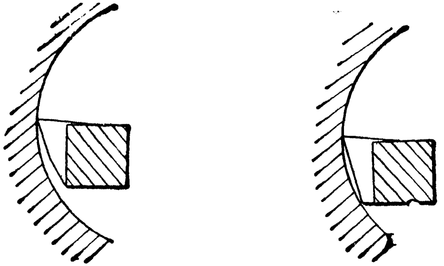


Fig. 124 Fig. 12[illegible]

Figs. 124 and 125.—Boring-tool Clearance

The remarks which are made as to cutting angles and clearance in Chapter XI. apply with equal force to boring tools.

In boring it is sometimes disadvantageous to put as much top rake as would be allowed in a turning tool for similar material; this is because the boring tool is long and relatively unsupported, and a keen angle of edge leads to chatter and vibration.

Holding Work for Boring from Slide-rest.—The account given of the methods of chucking on the face-plate and in various chucks in Chapter IV. of the companion handbook relates in many particulars also to boring. The only differences are that special care has to be exercised not to chuck a piece in such a way that the point of the boring cutter cannot emerge safely into a free space, when the tool may cut into the plate, or chuck, or spindle nose. And furthermore, the lateral pressure of a tool working at the mouth of a long article produces severe side pull, which may spring the work, or loosen it in the clamps or jaws. Extra care must be taken to obtain a tight grip, and supplementary clamps are sometimes advisable. Owing to the presence of the boring tool, there is no chance of affording end support from the tailstock, but the help of a steady is frequently possible. On long objects, such as tubing, spindles, etc., this arrangement is essential, if the ends require to be bored out truly. One end is secured in the concentric chuck, and the steady-rest is brought to the free end, the jaws being adjusted to centralise and support the outside without shake. For great accuracy it is safer to place one end upon the centre, and drive with a carrier, which necessitates tying the latter to the catch plate with cord or belt-lacing to prevent the spindle from slipping off the centre. The smooth exterior of the spindle is protected from damage by the steady jaws with a band of brass. The boring is then carried on, with certainty that the interior will be concentric with the exterior (Fig. 126).

A good deal of angle plate (*see* Chapter IV. of the companion handbook) holding is done for boring, this method furnishing a convenient means of clamping, of location, and of resistance to lateral pressure. The tool can be easily seen as it emerges from the back of the hole, and there is little or no risk of cutting into the faceplate.

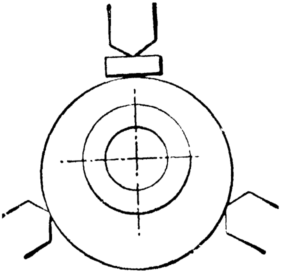


Fig. 126.—Boring Long Objects Held in Chuck

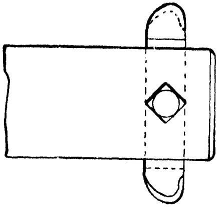


Fig. 127.—Double-ended Roughing Cutter

Roughing and Finishing Cuts.—As in external turning, the bold method is the one to adopt when boring out a hole. To nibble feebly at the interior is a very ineffective way, because the cutter is liable to come into contact with and to scrape over scale and sand, and its edge will suffer quickly. Some turners are apprehensive when they see the boring bar "dithering" and jumping on the roughing cut, but no notice need be taken of this if the bar is really stiff enough for the job. The next cut through will put matters right and eliminate the irregularities. At the finish-cut traverse there should be no interruption, but the feed should continue without intermission for any purpose until the end of the bore has been reached. Double-ended cutters are not generally employed for finishing passages with these slide-rest bars, for it is not easy to set them central to cut an equal amount on each side. But in the case of roughing cuts, where exact setting does not matter so greatly, there is advantage in running a double-ended cutter through; a good shape may be noticed in Fig. 127. This not only does the boring at a faster rate than a single-ended one, but also evolves a truer bore owing to the balanced cut.

Taper Boring.—A tool held in the rest can receive an angular movement to bore a tapered hole by swivelling the top slide, or by the use of one of the taper-attachment devices detailed in Chapter VIII. of "The Simple Lathe and Its Accessories." The first-named method is more commonly adopted, when the lathe does not possess a taper attachment. The length of travel of the top slide is usually sufficient for most of the taper boring required. Approximate angles are obtainable by reading off the graduations on the swivel base, while for accuracy it is necessary to make slight corrections after trials into the bore with a gauge or sample of work, feeling the amount of rock at either end, or testing with red-lead to ascertain the extent of contact. By laying a bevel against the faceplate it is easy to set the slide to a certain angle, which can, for instance, be taken off a matching piece of work (Fig. 128).

Another mode of setting consists of setting the slide angle approximately, and then running it up and down in front of the tapered piece, trying the coincidence by means of a scriber point pinched in the rest, or more easily and accurately with a test indicator.

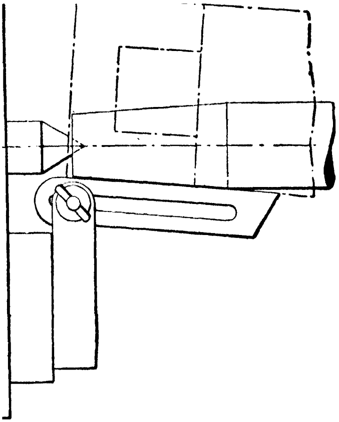


Fig. 128.—Setting Slide-rest for Taper Boring

In the event of a taper bore requiring to be duplicated, skimmed out a little larger, or continued in deeper, a simple method for showing the angle lies in placing a straightedge in the bore, holding it horizontally, and comparing the setting of the rest by its edge (Fig. 129). This is more accurate than endeavouring to run a pointer up and down the taper, holding the pointer in the rest. In cases where taper-fitting parts have to be turned and bored, the greatest accuracy is secured by leaving the rest swivelled after doing the one portion, and then proceeding with the other, thereby gaining an exact match of the tapers. There is no absolute necessity in long tapers to continue the fit all the way, so long as about a third of the distance at each end is left; the middle portion may be recessed out, and this lessens the trouble of fitting.

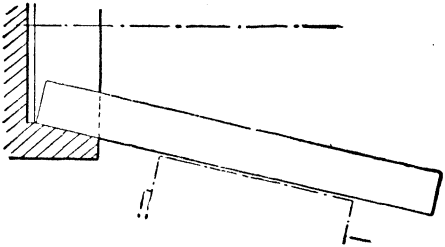


Fig. 129.—Setting Slide-rest by Means of Straightedge Held in Taper Bore

Boring with Bar between Centres.—This method is chiefly of value for objects that cannot be conveniently swung on the faceplate or angle plate, or that are too bulky to swing over the bed. When length is considerable the use of a bar offers advantages over the slide-rest tool method. Another point is that the number of cutters may be increased to quicken the feed, and secure balanced action. Very heavy boring can be accomplished with the back-gear thrown in. All sorts of operations are feasible with this method, including rough and finish boring, reaming, bell-mouthing, recessing, facing, grooving, outside turning, back facing, etc. The driving is a simple matter, involving only a carrier and catch-plate, and the only precautions that need be observed are to adjust the tailstock centre just right—not too tight so as to produce heating—to keep it well lubricated, and not to stop the lathe while a finishing cut is going through. Ample stiffness of bar is essential for rapid and accurate tooling, and the cutters should fit their holes nicely, be firmly pinched, and not overhang more than can be avoided.

Holding Work for Boring with Bar.—There is much diversity in the arrangements for clamping down work. In some instances the fastening down is simple, and accomplished in a few minutes, in others much trouble is encountered. The simplest case occurs when a casting has a foot that only requires simple packing up on strips resting on the saddle and ordinary plates are available for pressure on the flanges. But certain awkward forms entail troublesome packings of different heights at different locations, or the use of **V**-blocks or angle plates, while the bolts may require to be long, and the clamps of special shape to fit the contour of the casting. If the clamp pressure comes solidly on a flange, or deep section of metal inadequately supported on the boring table or its packings, there is no risk of distortion. When the clamps have to be slung round curves the bolt pressure must be carefully regulated, and the area of contact of the clamps made as large as possible, by fitting them to the curve, or laying wood packing between to prevent concentrated pressure. Adding to the number of clamps helps to neutralise the bad effects, because a greater number, say three instead of two, reduces the need for screwing down very tightly. It does not take much pressure to distort a pipe-like casting, and round boring is thereby rendered impossible. Laying the clamps around the flanges is sometimes feasible, and this applies the pressure where there is a much deeper body of metal to resist caving in.

Another vital matter relates to the close fitting of the saddle on the bed, or of the cross slide or the upper slide when these happen to be employed for holding articles for boring. The case is not quite on a level with that of turning, because the pressure on the tool is in a constant direction, while in boring the pushing-away effort of the cutter takes place successively all around the circumference.

In considering the means for securing a piece to be bored, much depends on its shape, as mentioned above, and also upon the relative capacity of the saddle. Some lathes are poorly furnished in this way, the saddles being thin and weak, and lacking in surface and bolting capacity, while others are thick and broad in area, with plenty of **T**-slots. A useful construction, where there is sufficient work to warrant the expense, is a special saddle fitted to the cross ways of the ordinary one, this saddle having a large surface besprinkled with **T**-slots. The advantage of this arrangement is that the whole area is available for fastening down to, and that the cross movement permits of adjustment to bring holes in line with the lathe axis, and to re-set for boring or drilling other holes parallel thereto. Another practice involves the provision of a plain slotted plate bolted down by its corners to the saddle, and possessing vertical adjustment through wedges or screws, the small degree of vertical setting thus available enabling exact heights to be arrived at. The limitation to either of these fittings comes in when they curtail the centre height too much, in which event the saddle surface must be utilised. On the other hand, pieces with base portions that do not reach far down can be accommodated upon the cross slide, or on a special plate bolted to it.

Yet another course brings the services of an angle plate into requisition; this is either fixed to the saddle, or to the cross slide, and capacity for vertical setting up and down the face of the plate offers a convenient movement.

If a casting, say of a tailstock or headstock, is too high to stand on the saddle, and overhangs considerably when laid on its side, the provision of long bars bolted to the surface may solve the difficulty, these bars extending out to the rear, and sustaining the base. Long levers, to be bored in the eyes, can likewise be secured, and it is also possible to arrange a sort of jig fitting in the shape of a locating pin at the rear, which enters the first bored hole as the job is reversed for doing the other end, and fixes the centre distance for duplicate pieces.

The Application of Clamps.— The severe nature of the boring operation in rough castings or forgings renders security of fixing imperative. One of the chief rules to remember is to locate the clamps as far apart as possible, that is near to the respective ends or corners, where the twisting effort is greatest. Much assistance can be derived from the inclusion of stop blocks or plates bolted to the saddle surface and pushed close to the edges or flanges of the article, so that it cannot slew round. For repetition work the blocks on one side may be allowed to stay, acting then as location spots. Such is also true of **V**-blocks, when employed for a succession of similar shapes. Even should slight alterations in location be desirable for each piece, the blocks are valuable as affording a nearly true position, and saving tentative adjustments.

What may be termed secondary boring operations crop up on occasion, where no change takes place in the attitude of the work. Bearings are typical examples, the holes, say, in a cast-iron frame being first bored, then the turned brasses or bushings inserted, and the bar put through these, with a suitably smaller cutter. Such a procedure is sometimes more convenient and desirable than completely finishing the bushings and placing them in. This applies also to separate bearings, which are best clamped at the same setting on the saddle, ensuring exact heights of each from the feet. All parts which are split with a half bore in each should be bored together, so that the bore is true when the two halves are finally assembled.

The Use of V-blocks.—When dealing with sizes that leave little space between the underside of the curve and the face of the saddle, the ordinary **V**-block obviously cannot be made use of, since it would raise the centre of the work too high. Usually a low type of block has to be made for lathe boring, such as is proportioned in Fig. 130, forming the angles to less than the usual 45 degrees. A pair of solid blocks like this does not provide any means of vertical alteration excepting by placing packing beneath. But if the blocks are formed in halves, not only can they be applied in restricted places, but they provide facility for vertical adjustments; this is clear from Fig. 131,

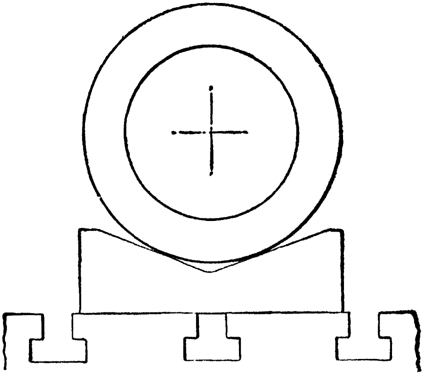


Fig. 130.—Low Supporting V-blocks

showing wooden half-blocks supporting a bushing. The blocks are placed closer together, or farther apart, as desired, to raise or lower the bush, and being then secured with the nuts on the bolts, the clamping plates and their wooden packings are laid on and the nuts set down. If much of this class of gripping has to be done, **V**-clamps (A) are better, and do not need such long bolts.

Preparing Work for Boring.—The extent to which marking out is necessary on a rough casting or forging depends on many circumstances, including the available allowances for tooling on different portions, the errors in the material arising from faulty setting or displacement of cores, the inaccuracies in forgings, and the question as to whether the flat surfaces are tooled before or after boring. If a casting is of a simple character, there is no need to take any great amount of trouble; the casting is bolted on to the saddle by its flat face, with packing as required, and the bore adjusted to come concentric with the boring-bar. When lack of parallelism exists between the bore and the flat face or faces, or the latter will not clean up safely, a certain amount of averaging must be done. The ends of the bore are bridged with wood bars, whitened on the face, and callipers used to find the centre of the bore as a preliminary test (*see* Fig. 132). The longitudinal axis may thus be checked to see if it is parallel with the foot. Should it be badly out, so that planing the foot true would thin the flange too much at one end, the centre on the wood will need to be "thrown" sufficiently, as shown by A (Fig. 132). From this centre a circle is struck on the whitened end of the cylinder, and one at the other end, the cylinder being packed up accordingly to bring the altered axis level. When there happens to be plenty of thickness on a foot or flange it may be preferable to keep to the axis of the bore in the rough casting, and plane the flat surfaces in accordance with the results of the boring. Complications which arise from the presence of other flanges, or holes, or bores, will often exercise a determining influence. Centre distances of adjacent bores

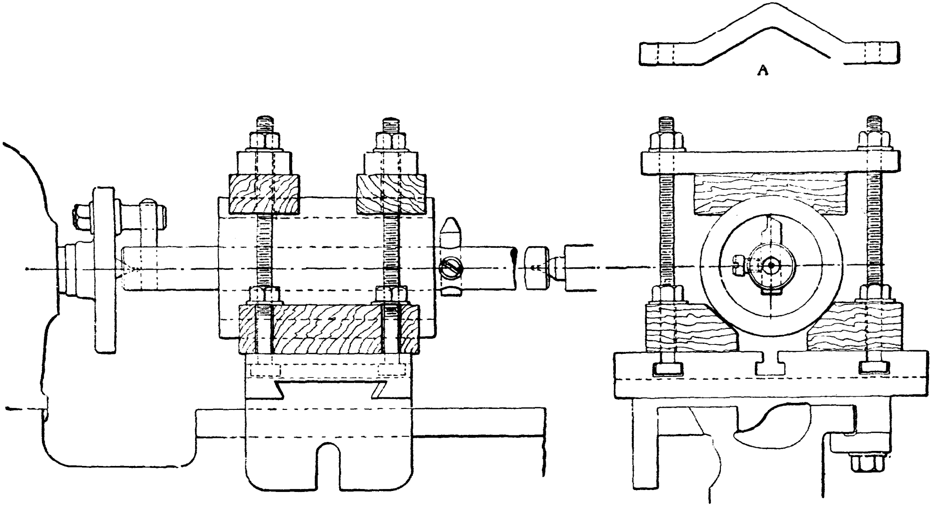


Fig. 131.—Wooden Half-blocks Supporting Bushing

are usually particular, and the first care is to see that they come right, leaving enough metal to clean up to a nice surface.

In the majority of cases the setting into position of the work either goes by the axis of the rough hole or, if marked out, by the end circles. Several methods are available for securing easy setting. One simple method lies in the use of the concentric chuck, by holding the inside of the work on this, noting that it runs truly, and then bringing up the saddle and arranging the packings and clamps to bind the article while thus presented truly. The large or pipe centre (*see* Chapter III. of the companion handbook) may perhaps be put in the tailstock to sustain and centre the back end of the bore, if long. If a mandrel happens to be handy that will just fit the bore loosely, this can be set between centres and left until the packing

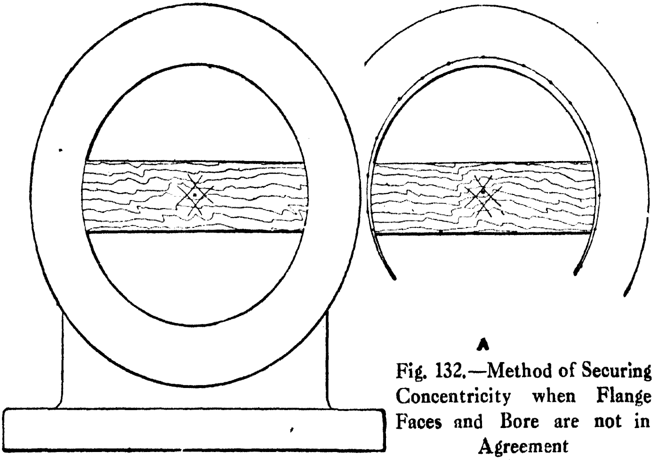


Fig. 132.—Method of Securing Concentricity when Flange Faces and Bore are not in Agreement

up and clamping has been effected. Or two large pipe centres will answer the same purpose.

Leaving the bridge-bars in position after marking out permits the use of the lathe centres for setting, by running the cylinder up to the headstock centre, and bringing the tailstock up to the hindmost bar. The centres marked on the bars (Fig. 132) thus provide accurate testing points for alignment in the lathe.

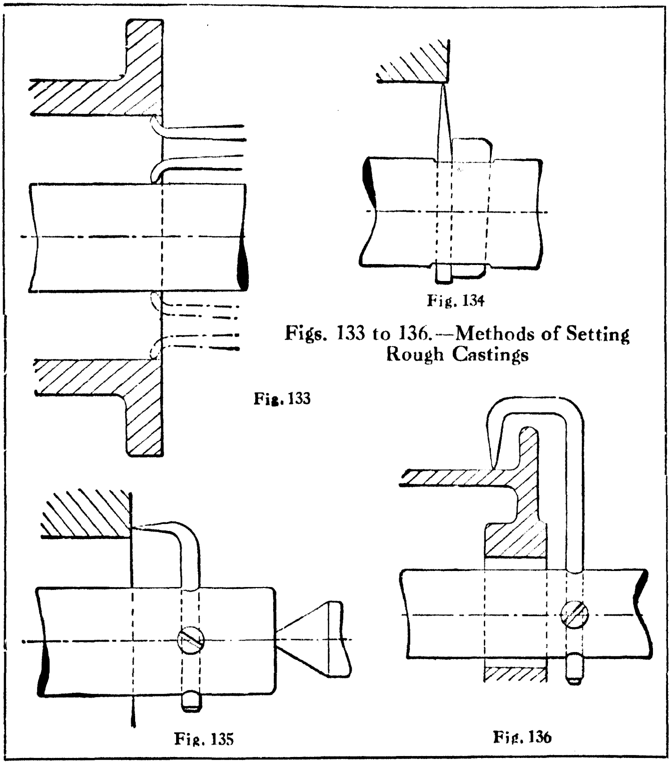


Fig. 134

Figs. 133 to 136.—Methods of Setting Rough Castings

Fig. 133

Fig. 135

Fig. 136

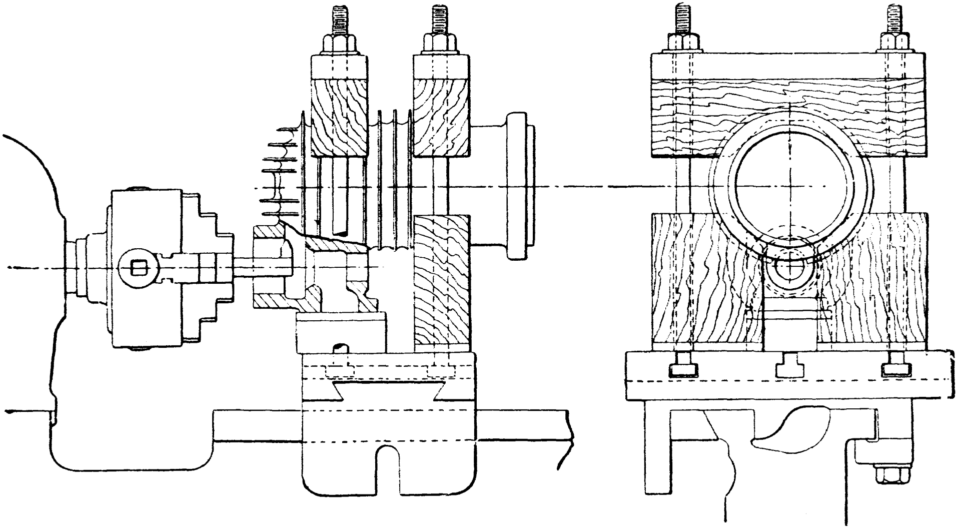


Fig. 137.—Method of Boring from Headstock

With the centering bars absent, the location by the rough hole is readily performed from the boring bar by callipering at three or four spots (*see* Fig. 133). By wedging a pointer into the bar, as at Fig. 134, to just clear the diameter of the bore, the concentricity of the latter is also observable; in place of wedging, a set-screw (Fig. 135) is a convenient alternative. A matter that may be noted here is the very occasional necessity for boring concentrically with a cast exterior, when the latter is required to run fairly true, such as in chain or rope winding drums, for example. A hooked pointer comes in for this purpose, the portion being sufficiently cranked, if necessary, to reach around a flange (*see* Fig. 136).

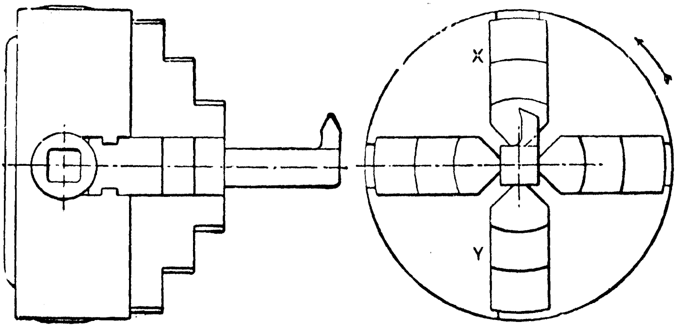


Fig. 138.—Adjusting Boring Tool Held in Chuck

Boring from Headstock.—A somewhat unusual way of boring a hole—from the headstock—is worth mentioning. The job is bolted to the saddle and fed along, while a tool gripped in the four-jaw chuck revolves and cuts out a recess or bore, without necessitating a special drill or reamer. Any kind of fit can be made in this way at small expense, and threads can likewise be cut in a similar manner. Figs. 137 and 138 show the operation as performed on a Drummond lathe. A cylinder, clamped down on **V**-blocks and packing, presents the valve cap seating for opening out and threading. The tool used has a square shank, and is adjusted for diameter of circle by moving the jaws X Y of the chuck (*see* Fig. 138). Slacking back X and tightening up Y throws the tool out to a larger radius.

CHAPTER VII

Measuring Turned and Bored Work

To attain the perfection of working mentioned earlier, the mode of testing for diameter must be definite and properly carried out. Having fixed upon the finished diameter, a certain allowance should be settled upon for the final cut, and an accurate setting be made of the measuring tool to this size. A cut is then started tentatively on the end and the size tried, and if need be the tool set in farther until correct, after which the feed is thrown in.

When making use of callipers for trying the roughing-out dimensions, the best way is to set another pair for this diameter and keep the finished size on a best pair, set very carefully and laid aside until required. There will then be no confusion, and everything will be ready for a definite line of action. On repeated pieces this procedure is still more valuable, and avoids risks of spoilt work. Time can be saved when there happens to be several identical articles by roughing them all out at first, and then finishing as another batch; this enables one to keep separate tools in the best condition for the respective cuts, and avoids waste incurred in changing tools and altering the diameter of cut.

The greatest help in carrying on turning expeditiously and accurately is the micrometer calliper. It is more precise than waiting until the plain callipers will slip over, in which circumstances the actual excess in size is not at all certain nor ascertainable. When the lathe happens to be provided with an accurate cross-feed screw, with micrometer dial, the use of this does away with some of the necessity for so much reference to the micrometer calliper, as sizes can be repeated by definite settings of the dial, and the relations between roughing and finishing cuts be determined. In cutting threads, grooving, etc., the dial is very useful for obtaining successive increments of depth at succeeding traverses, or repeated depths of setting-in at various locations, these being measurements that are not easy to test and measure in any other manner.

The larger the callipers the greater the risk of errors creeping in through this occurrence. The detection of cross working is also a matter for the sense of touch, the callipers being sighted fairly, and also worked gently to right and left until the easiest position is found. The practice of widening the points tends to lessen this difficulty, but such widening must not be overdone, or a clumsiness of feel will result, the area of contact being too extensive.

Using the Micrometer Callipers on Lathe Work.—This instrument should never be applied until the work has been brought completely to rest in the lathe, and then the application should be made in a free and flexible manner, letting the anvils float, as it were, until they seat themselves accurately upon the work.

False measurements must be guarded against, such as those arising from the presence of dirt or grit on the anvil faces or on the work, little upstanding slithers or roughness upon steel or brass, or poor wrought iron. If the micrometer has a ratchet or friction stop, so much the better for securing accurate and uniform measurements; if not, the pressure must be nicely regulated to avoid getting too tight a fit or of springing the frame. Some workers are prone to the bad habit of working the anvils to and fro across the piece, in imitation of the use of plain callipers, but there is no necessity at all to do this, and it scratches and wears the delicate anvil faces.

A brief explanation of the mode of reading the graduations may be offered. The principle of these is extremely simple, the twenty-five graduations around the bevelled end of the thimble being adopted in conjunction with a screw thread of forty to the inch. The movement from one graduation to another as viewed against the horizontal line on the sleeve therefore means that the anvil has travelled one-thousandth of an inch. A complete revolution of the thimble equals one-fortieth, or ·025 in. After the first revolution from zero the user would be bothered in remembering the number of turns he had made, hence vertical lines are marked on the sleeve at intervals corresponding to each turn, and the fourth lines are numbered, indicating thus an opening of $\frac{1}{10}$ in. The habitual user reads the size at a glance, but at first it is necessary to think it out, multiplying the number of vertical divisions visible by 25, and adding the number of thousandths indicated on the sleeve if it has gone past the zero line. A sample reading is shown in Fig. 139, this being ·304 in., that is, ·300 in. on the sleeve, plus ·004 in. on the thimble, which has retreated from the 3 division by the distance of four spaces. With a micrometer in good condition, half-thousandths may be read accurately by stopping the thimble half-way between divisions.

Gap Gauges and Limit Gauges.—Equipped with plain callipers and micrometer, the turner is able to cope with all the usual measurements. The fixed gap gauges and the limit gauges are not necessary excepting for workshops dealing with a large run of standard or repetitive work. Gap or snap gauges have openings of fixed width, and save the trouble of setting callipers and the wear on micrometers. Limit gauges are a more specialised type of measuring tool, having openings ground or adjusted to high and low dimensions, which thus control the size produced and maintain every piece within these limits.

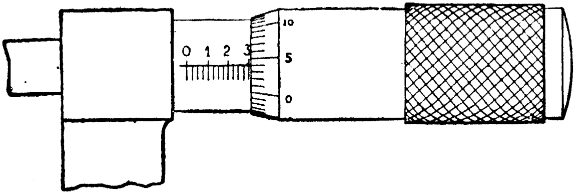


Fig. 139.—Micrometer Reading

The principal value of gap gauges for ordinary operations lies in their employment for small batches of similar sizes, saving the risk of movement taking place with jointed callipers, and also for awkward or restricted situations into which the plain callipers cannot be introduced, or for which the anvils of the micrometer are too wide. Narrow spaces such as the one at A in Fig. 140, or the width of internal grooves B, are cases in point. The former can be easily measured for diameter on the neck with a sheet-metal gauge filed out to the required size, and the latter be measured for width and location in regard to the outside faces by a tongue gauge shouldered as seen. For the companion fit of the tongued element over which B is mounted, another sheet gauge C is filed. These gauges also reveal the diameters at X in relation to those at Y already bored or turned. If only one or two specimens of this class of work are in question, the making of gauges may perhaps be dispensed with, the outer parts (eccentric straps, for instance) being first tooled, then separated, and one-half used as a gauge for the width and groove depth.

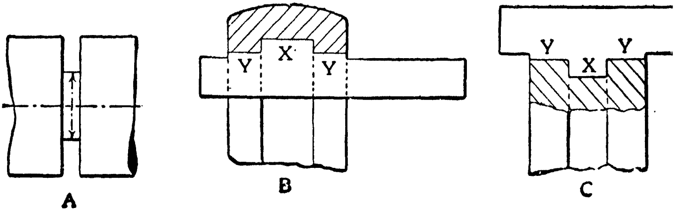


Fig. 140.—Methods of Gauging with Sheet Gauges

Profile Gauges.—Other types of sheet-metal gauges comprise those for testing profiles, including straight and tapered sections, and curves or combinations of curves with straight parts. Such gauges are filed up by reference to a drawing or to a sample job. There is a risk of getting wrong diameters in using some of these curve gauges, due to turning off too much at one end of the piece and so letting the gauge fall down. The profile will be all right, but it will be twisted in relation to the lathe centres. The safest plan to prevent such a fault lies in definite reduction at each end of the work at first on shoulders or large or small diameters, which need not subsequently be touched, or scarcely so, and serve as references or safety spots.

Testing Flat Faces.—With a cross slide in good condition, little anxiety need be felt as to the flatness of surfaced work. On the larger areas, and in examples where it is imperative not to have either hollowness or convexity, a little care becomes essential in testing for flatness. The most accurate device is that of a straightedge in combination with tissue-paper (*see* Fig. 141), strips of which are laid under the straightedge and pulled gently to see if they are all held with an equal pressure. A point that needs to be mentioned with respect to the facing of large areas intersected by holes or slots is the effect of these upon the smoothness and accuracy of the operation. It is rather difficult to set up the thrust bearings of the headstock spindle with such a niceness that there will be no end play as the tool comes opposite a gap in the metal; the evident result of this will be an irregularity in the action of the cut, and the face will not be true or smooth all over. A remedy for this state of affairs is to interpose a piece of rod between the pair of centres, and adjust the back one until the end play is entirely absorbed. The tool may be then fed across a faceplate or chuck casting or other object possessing slots or similar interruptions in the surface without detriment to the process of facing.

Testing a Bore.—Ascertaining the diameter of a hole is rather more difficult than measuring an exterior, because the callipers get crosswise and one cannot readily feel when they stand fair. The safest way is to hold one leg steadily at the bottom of the curve, and vibrate the tool so that by the feel of the other point the easiest spot of contact is ascertained (Fig. 142), that is, the full diameter. This cannot be claimed as a process that anyone may acquire with certainty, and when the other errors involved in transferring the dimension to the outside callipers, and trying these on the part that fits the bore, are added, there occurs plenty of scope for bad fitting. The use of a Whitworth plug gauge provides a better means of measurement, as this fits the hole, and likewise gives a test of circularity. But a gauge of this class is useless until the bore is practically finished; in other words, it does not afford any guide as to the amount to be removed just before the full diameter is reached. This is where the callipers are useful as a supplementary aid to the gauge. In the absence of the latter, the actual work may be tried in the hole, or a piece of standard shaft when boring work such as bearings may

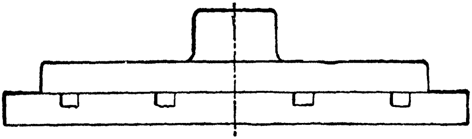
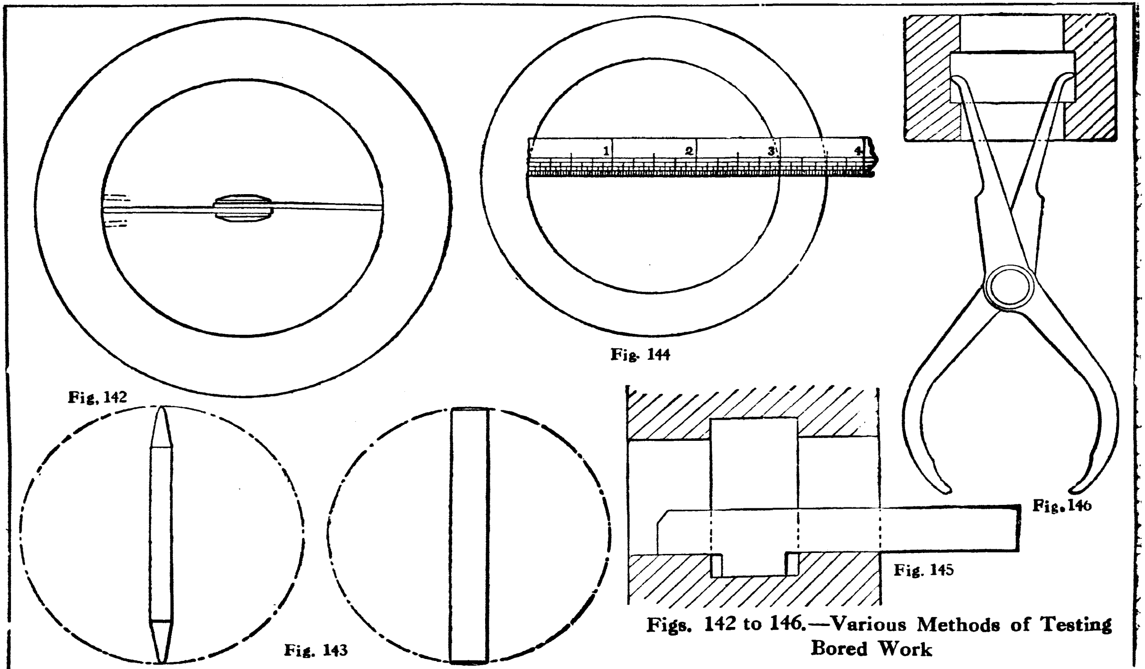


Fig. 141.—Straightedge and Tissue-paper Test for Surfaced Work

be used. Other measuring instruments include a rod gauge, and the inside micrometer. The former is either made solid, with the length finished off as points (Fig. 143), or kept to full diameter and finished with spherical terminations. An adjustable rod gauge is useful, and may be made of two telescopic pieces of tube, which permits of different standard diameters, and also of variations in fits. The internal micrometer is a type of rod gauge with a fine screw and a graduated thimble, a refined form that enables measurements to be taken with exactitude. There remains to be mentioned the ordinary steel rule as a medium for testing bores, and it is surprising how accurate this is when applied properly. Accurate measurements of bores may be made by hitching the end gently into the hole (Fig. 144), and reading the graduation opposite the other side. By looking fairly end on, a very slight deviation from the required graduation is easily observable.

If chambering out or recessing is done the abovementioned measuring appliances cannot be applied. The diameter must be checked by reference to the other portion of the bore, with a step gauge, as in Fig. 145. This frequently satisfies requirements. Or, should precise callipering be demanded, the callipers of "in and out" pattern are used, the inside legs being set into the recess and the equivalent noted between the outside part that hangs from the bore (*see* Fig. 146).

The other kind of testing (for lengths) is effected with the rule from the face of the piece; with a hook



Figs. 142 to 146.—Various Methods of Testing Bored Work rule, which is better; or with a notched gauge that hitches over an internal corner. To get repeated depths on a number of castings or forgings a stop may be arranged to arrest the saddle or top slide at a definite spot, or the face of the job can be used as a datum surface, which ensures positive accuracy. Two methods of arranging stops are illustrated by Fig. 147; in the upper view a piece of bar is pinched on the rest, together with the boring tool, the projection of the bar being such that it comes to the work face at the correct time. The lower view shows a plain stop-collar affixed on the tool.

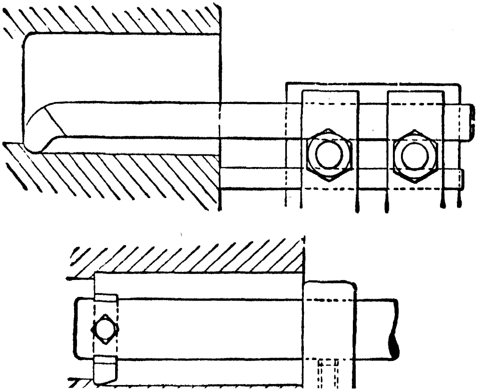


Fig. 147.—Stops for Boring Hole to Given Depth

CHAPTER VIII

Screw-cutting in the Lathe

To adequately deal with the process of screw-cutting in the lathe would require a volume quite as large as the present one, and the purposes of this handbook will be sufficiently served if the principle of the leading screw and methods of working out change wheels and cutting the various threads are explained, referring the reader to " Screw-cutting " (Cassell's Workshop Series) for detailed information on all branches of this interesting subject.

Principle of the Lead-screw.—The pitch of the guide or leading screw of a lathe has an important and direct relation to the number of threads to be cut. Lathes intended for screw-cutting are provided with a carriage (sometimes called the saddle), which is capable of being traversed collaterally (parallel) with the lathe bed, the rate of progression being dependent on, and varying with, the number of threads per inch to be cut. The carriage accommodates the slide-rest, wherein is fixed the screw-cutting tool.

If the screw to be cut is a right-handed one, the motion of the saddle is from the loose to the fast headstock, and the guide screw must then revolve in the same direction as the screw being cut.

In cutting a screw of left-hand pitch, the saddle would travel in the opposite direction, which reversion is effected by using an additional intermediate wheel. An intermediate wheel, it should be noted, is both a driver and a driven.

Two methods of screw-cutting are in vogue—simple and compound. The simple method consists of one driver, placed on the lathe spindle, and one driven, which is placed on the leading screw, any convenient wheel being used intermediately to gear up. The use of the latter does not affect the pitch of the screw to be cut in any way, merely serving to transmit the correct velocity ratio (or ratio of speed between spindle gear and leading-screw gear) from the driver to the driven.

In a compound gear, however, four wheels are used, two drivers and two driven. Either of the drivers is fixed on the lathe spindle, and gears with one of the driven, which is placed on one of the studs of the swing frame. The second driving-wheel is pinioned to the stud, and gears with the remaining driven wheel, which is placed on the leading screw. The ratio of drivers to driven is equal to the ratio of the pitch of the leading screw to the pitch of the screw to be cut, hence the number of teeth in the drivers is determined by, and found from, the pitch of the leading screw, and the number of teeth in the driven wheels are similarly found from the pitch of the screw to be cut.

The number of teeth in lathe wheels usually rises from 15 (which is the smallest practicable number of teeth it is possible to have in a gear) in regular increases of 5 up to 100, and from 100 to 150 in regular increases of 10. Therefore the pitches of the leading screw and screw to be cut must be multiplied by either 5, 10, 15, or 20 to obtain the numbers of teeth in drivers and driven respectively.

It should be remembered that both pitches must be multiplied by the same number, when simple wheels only are being dealt with.

Example.—What change wheels will be required to cut 8 threads per inch, pitch of leading screw being ½ in.? First find the least number of complete threads of leading screw that in linear measurement is equivalent to a similar linear distance on the job to be cut that contains a complete (not fractional) number of threads. In the example there are 2 threads per inch of leading screw, and 8 per inch of thread to be cut. Hence:

2 × 10 = 20 drivers
8 × 10 = 80 driven.

Example.—What wheels are required to cut 4½ threads per inch with a leading screw of ¼ pitch? Here 9 threads of screw to be cut equal in length 8 threads of the leading screw:

8 × 5 = 40 drivers
9 × 5 = 45 driven.

For a series of four wheels the same threads could be cut by using an extra driver and driven with equal number of teeth. Thus:

8 × 5 = 40, 50 drivers.
9 × 5 = 45, 50 driven.

Or, if it is not practicable to use two wheels of the same size, multiply the threads of the screw to be cut (8 in the above example) by 10 and the leading screw number by 5, choosing any wheel of convenient diameter for the second driver, and one twice the diameter of the latter for the second driven. The wheels would now be:

8 × 10 = 80, 50 drivers.
9 × 5 = 45, 100 driven.

It will, of course, be clear that there are many threads which cannot be cut when a simple train is used. In these cases the compound method is used. Assume that an odd pitch is being cut, as, for example, 6⅔ per inch, leading screw 2 per inch. Here 20 threads of screw to be cut are equal in length to 6 of the leading screw. Hence it is said:

6 × 5 = 30
20 × 5 = 100.

If the 100 wheel is too large, the wheels can be "brought down" by factorising the threads thus:

3 × 2 = 6
5 × 4 = 20.

Multiply each factor by 10, and the compound wheels are found thus:

30, 20 drivers
50, 40 driven.

These are arranged in the manner referred to in an earlier paragraph.

It is a simple matter to prove wheels, if uncertainty exists as to whether a given series of wheels will give the required lead. The driven wheels should be multiplied together, and the product multiplied by the threads per inch of the leading screw. Divide this result by the product of the driving wheels, and the answer should be the number of threads per inch to be cut. In the last example given there are two threads per inch, and the product of the driven wheels is $50 \times 40 = 2{,}000$. Multiplying this by the threads per inch of the lead-screw gives 4,000. The product of the drivers is 600. Hence, $\frac{4{,}000}{600} = 6\frac{2}{3}$, which is the required number of threads to be cut, and thus the drivers and drivens are correct.

Metric Pitches.—It is quite possible to cut metric pitches in lathes not fitted with a metric leading screw. A change wheel possessing either 63 or 127 teeth would be required, since the ratio between the metric measurement and the pitch of the English leading screw is $\frac{63}{800}$ for ½-in. pitch, and $\frac{63}{400}$ for ¼-in. pitch.

To determine the change wheels required for, say, 10-millimetres pitch, the pitch of the thread to be cut is multiplied by 63, and then divided by either 800 or 400, according to the pitch of the leading screw.

Thus, assuming a 10-mm. thread to be cut on a lathe with a ½-in. leading screw, $\frac{10 \times 63}{800} = \frac{630}{800}$. This conveys the ratio of the change wheels required. Therefore $\frac{630}{800} = \frac{63 \times 10}{40 \times 20} = \frac{63 \times 25}{100 \times 20}$. Here two of the factors have been multiplied by 2½.

Multiple Threads.—In cutting multiple-threaded screws, worms, or even hobs, the turner is usually relied on to make provision for the division of the blank to locate the positions of the starts. If a double thread (sometimes called a "double-start" thread) is being cut, after the first thread has been cut, the change gear is divided and the two teeth marked with chalk. The tooth space, into which the gear enters, is also marked. The swing frame is then lowered, and the lathe spindle turned round until the next marked tooth is coincident with the chalked space of the gear that meshes with it. It is thus certain that the carriage and screw-cutting tool are in the correct position for cutting the next thread.

"Picking-up" Threads—When cutting threads whose pitch is not an aliquot part of the leading screw, it is necessary to have some method of "picking-up" or catching the thread if it will be necessary to take more than one cut. If the leading screw is 2 threads per inch (t.p.i.), the clasp nut can be thrown in at any portion of the traverse for either 2, 4, 6, 8, 10, 12, 14, 16, etc. Hence, when the number of threads to be cut can be divided by the number of threads per inch of the leading screw without a remainder, the clasp nut will engage at any portion of the leading screw.

In cutting a number of threads per inch which cannot be so divided, the least common multiple of the pitches concerned is found. As an example, assume that a thread of $\frac{5}{8}$-in. pitch is to be cut on a leading screw of 2 t.p.i. In this case there are $1\frac{3}{5}$ t.p.i. The pitch of the lead-screw is $\frac{1}{2}$ in.; therefore, multiplying the numerators together $\frac{5}{8}$ and $\frac{4}{8}$, the minimum length in which there will be a complete number of threads in both leading screw and thread to be cut will be $\frac{5 \times 4}{8} = 2\frac{1}{2}$ in.

The clasp nut may be thrown in gear at 2½ in., 5 in., 7½ in., and so on. In the case of a ⅝-in. pitch screw shorter than the minimum of 2½ in., the carriage must be traversed back 2½ in. Should it be 4½ in. long, traverse the carriage back 5 in.

It is customary in many workshops to run the saddle back to the movable headstock, and then to make a mark on the leading screw. A mark is similarly made on the faceplate.

In picking up the thread for a second or third cut, as the case may be, the saddle is run back to the headstock, and the lathe is then permitted to run until the marks on the leading screw and the faceplate come to their relative positions. The clasp nut is then thrown in.

Cutting Left-hand Screws.—In cutting left-hand screws it is necessary to place an additional change wheel between the driver and driven wheels to impart the left-hand motion.

Some lathes are provided with a plate carrying three wheels of small diameter, which can be so geared that either of the upper two may be placed in mesh with the mandrel pinion, hence imparting a left-hand or right-hand motion as desired.

Prime Number Threads.—Any prime number of threads per inch can be cut with leading screws of 2 or 4 t.p.i., but not with a leading screw of 3 t.p.i. without nullifying the prime numbers, which are not multiples of 3 with a wheel based on them.

CHAPTER IX

Gear Cutting and Milling in the Lathe

Gear Cutting.—A spur wheel can be cut in an ordinary screw-cutting lathe, providing there are at hand the necessary attachments for the purpose. The special devices necessary are described and illustrated in Chapter VIII. of "The Simple Lathe and its Accessories." First method: a milling cutter of correct shape and size of space between the teeth of proposed spur wheel is fixed to an arbor or mandrel between the lathe centres, and driven with the back-gear in. Then on the surfacing slide of the slide-rest or saddle is secured a vertical slide carrying an attachment with a fixed head, on which is a division plate or counter for moving the blank wheel round the exact amount for the next tooth space to be cut. The wheel is, of course, driven on a short mandrel, the top end of the latter being attached to the spindle of the dividing apparatus, while the bottom end is fixed to a back centre or small poppet similar to the poppet of the lathe itself. It will be obvious by this method that only a limited diameter wheel could be cut. The second way is to mount the wheel blank on a mandrel between the lathe centres, and use a milling cutter fixed on a vertical spindle, on which is a worm wheel driven by a worm on a horizontal spindle with a small pulley for a 1¼-in. belt driven from overhead gear. The whole apparatus is in a frame (styled a milling cutter frame), and is fixed in the slide tool-holder. With this arrangement a dividing apparatus is also necessary. A third method is as follows: Mount the wheel blank on a spindle between the lathe centres, holding the spindle rigid in the four-jaw chuck. Now assuming the wheel to be cut contained twenty teeth, then if a 20-toothed wheel were fixed on the lathe spindle, and an improvised " stop " or counter fitted to spring into the space between the teeth, then by lifting back the stop and turning the lathe spindle one tooth, and dropping the stop again, the wheel blank would be moved with it the correct distance for another space to be cut. The actual cutting is done as follows: A tool similar to a round-nosed parting tool is fixed on its side in the tool holder and fed by the surfacing slide; but the cut is taken as in a shaping machine, by moving the saddle forwards and back by means of a long wrench or hydraulic-jack handle fixed to the rack and pinion motion of the saddle. After the twenty divisions have been cut to the required depth, a second, or finishing tool, is used, filed, of course, to the correct curves of the tooth profiles, and used to skim up the spaces in the same manner. This method, while not requiring any elaborate apparatus, is still rather a tedious method of performing the work; but with reasonable care the work should be fairly accurate.

In a further method the blank A (Figs. 148 and 149) is turned up and a line cut on one face showing the diameter at the root of the teeth. A change-wheel B from the lathe is now selected, having the same number of teeth as the finished spur-wheel (or some multiple of the required number), and a mandrel C made to take both the wheel and blank, as shown in Fig. 148. A cheese-headed screw D, the head of which is a good fit in the keyway, locates the change-wheel in a rotary direction, while allowing it to slide to and fro for tightening up.

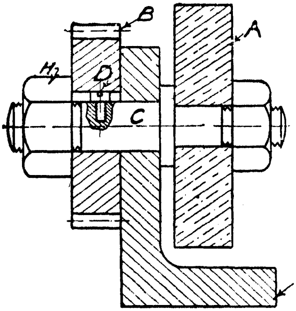


Fig. 148

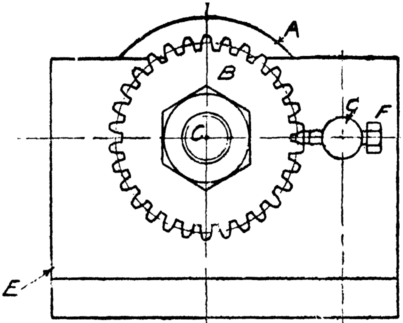


Fig. 149

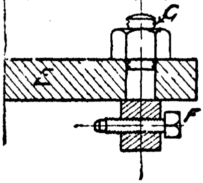


Fig. 150

Fig. 148.—Sectional Side Elevation showing Blank Mounted Ready for Cutting

Figs. 149 and 150. — Front Elevation and Part Section showing Bolt and Screwed Stop-pin

The angle-plate E is now drilled to receive the mandrel C, the vertical centre line of this hole being clearly and permanently marked on for setting-up purposes. A smaller hole is provided in any convenient position to take the bolt G, which carries the stop pin F screwed through it, as shown in sectional plan by

Fig. 150. This hole may conveniently be elongated, to take various diameters of change-wheels.

A template must be made of a tooth space to suit the given pitch, the centre line being clearly marked on. The tool is made to this, the centre line on the template being continued along the tool-shank, and permanently scored in. The tool having been properly backed off and hardened, the parts can be assembled for cutting.

First set the angle-plate up in the machine so that the vertical face of it is at right angles to the path of the tool, that is, parallel with the edge of the bed. Line the tool up with the vertical centre line of the mandrel-hole, remove the stop-pin F, bolt the blank A firmly on to the mandrel, and put the latter in place; D is now replaced, the change-wheel B put on, and the stop-pin F screwed into a tooth space. Tighten up the nut H, and cut down to the line showing the tooth depth.

To make the next cut, supposing the change-wheel to have the same number of teeth as the spur-wheel, screw F back, slacken off the nut H, rotate one tooth, screw F in again, tighten up H, and proceed as before. It is a good plan to chalk every tooth space of the change-wheel B into which the stop-pin F has entered, especially if B has twice or three times the number of teeth as in A, as in those cases the appropriate number of spaces, one or two, must be missed.

The rig having once been made can be used indefinitely, as all the lathe wheels are interchangeable, and any blank can be bored to suit the mandrel first, and opened out to the finished diameter after cutting the teeth.

Milling in the Lathe.—Milling as practised in the lathe is more or less an expedient resorted to only when other means are lacking. Appliances for milling in the lathe are very fully discussed in Chapter VIII. of " The Simple Lathe and its Accessories."

Some forms of milling may, however, be effectively done in a lathe, notably end or edge milling, key grooving, etc. By using an end mill it is quite practicable to mill keyways in shafts, the cross feed being used to obtain the length of key groove desired. Such a length would, of course, be strictly limited to the total movement of the feed-screw; thus if the screw had a maximum travel of 6 in., then a key groove 6 in. long could be cut.

This also refers to edge milling in the lathe, the work being bolted down to the top of the slide-rest, its height being arranged to coincide with the axial line.

Small plain-milling operations are also capable of being carried out in the lathe. The cutter would in this case be mounted on an arbor, and carried between the centres, the work being secured to the slide-rest. These operations, however, must necessarily be of a very limited character, since it will be apparent that any vertical-feed adjustment is impossible to obtain on a slide-rest; screw slotting, and some forms of grooving or slitting, may be done quite well providing the work can be arranged at a given height.

CHAPTER X

Turning Ebonite

In turning ebonite correctly bear in mind the following: A high speed, a finely tempered tool and a slow and careful cut. The high speed is essential if the ebonite is to be polished straight from the tool. The tool itself should be made of high-speed tool steel, and a deep cut should never be taken, otherwise excessive heating will take place.

Overheating must never occur, as this will cause the sulphur to be drawn out of the ebonite, leaving a badly-pitted surface that will be found impossible to rectify by any such means as emery-paper and brick-dust.

The ebonite-worker must watch for any signs of heating, which is always accompanied by a pungent smell. Heating is the most serious trouble to contend with, as a little impatience to get the last cut finished will result in a scored surface and spoil perhaps several hours' work.

With regard to the most suitable tools, a round-nose tool with a good clearance will be found adaptable to almost every job. A specially well-made and selected tool, however, should be kept for taking the finishing and polishing cut. All tools must be kept sharp by means of an oil-slip. If they are allowed to heat up the temper will be lost, and the cutting edge of the tool turned up and ruined.

Turps may be used as a lubricant to minimise heating, if desired, but is not necessary if care is taken not to exceed the limits of speed and depth of cut.

The most successful polish is obtained by simply taking a very light cut with a super-tempered tool and moving the slide-rest so slowly that no " tool-lines " are visible in the ebonite.

A good deal of practice will be necessary before a perfectly-finished piece of work is produced, and a number of minor troubles will crop up which will only be got over by constant practice.

The slide-rest must be moved along at a uniform speed, otherwise patches of polished surface will be joined together by spiral scratches where the speed of the slide-rest was varied or the movement jerky. This trouble can be eliminated if the worker has a screw-cutting lathe. In this case the gears can be arranged to give a slow speed to the lead-screw, and the slide-rest run up by power or " self-acted," giving a uniform movement to the tool. Naturally, the ideal is to have the work revolving at a high speed, and the slide-rest moving as slowly as possible. This is most essential when the diameter of the work is large.

Another trouble which is frequently experienced if the work is of large diameter and fairly long is that due to heating, etc.; the tool suddenly gets blunt and spoils the last inch or so of ebonite. To reduce the chance of this occurring the work should be carefully watched, and the hand kept on the cross-feed of the slide so that the tool can be withdrawn from the work the moment any trouble is apparent.

In ornamental hand-turning great care must be exercised at first in order to get the right cutting angle, otherwise the tool will chatter violently or chip the ebonite.

Most of the ordinary hand-tools will be found suitable for ebonite. Naturally, owing to the shape of the work and the fact that the slide-rest cannot be used, it will be found impossible to polish with the tool alone. The work should, therefore, be turned up to size, all scores and scratches being removed as much as possible, and then a piece of FF emery-paper is run over the work, plenty of turps being used to prevent overheating.

After all the bad marks are removed a finer grade of paper, such as "blue-back," is used, again taking care to have plenty of turps. The final polish is obtained with a piece of fluffless cloth and tallow.

The finished work should be free from scratches and spiral lines left by the emery-paper.

Some workers use brick-dust and water before the tallow, and in some cases this is found desirable. The main point to watch is not to press too hard with the emery-paper, and never to let it touch the surface of the ebonite without plenty of turps as a lubricant.

Experience will show that the turps has a habit of drying off very suddenly, and unless this is watched the result will be a badly-scratched or pitted surface.

Ebonite varies considerably in quality, and some samples will be found to polish much easier than others. It will be found to vary also in hardness, sometimes chipping considerably.

CHAPTER XI

Cutting Tools and Tool-holders

SOME experience of the action of various shapes of tools is necessary when undertaking the wide range of processes it is possible to perform on a lathe.

When metals or alloys are found to be very hard all through, or in spots, the lessening of the cutting angle may be imperative; but it is not an economical procedure temporarily to alter the angle of a solid tool in such circumstances. The solid tools should be maintained at the most useful standard angles for ordinary work, and special difficulties be solved by using only the small bits of steel required for the holders.

The Tool Edge.—The principles of the tool edge is the same whether solid-forged ground tools or holders with cutters are in question. The three primary angles are those of top rake, front rake, and side rake, the latter being absent in some types of tools. In the ordinary English design of slide-rest top, with a fixed level surface, these angles remain unaltered, as they happen to be ground, but with the American swivel-shoe tool-post it is possible to modify the angle of presentation to the work by tilting the shank up or down, which has the result of lessening the effective angle of front rake in the first case and of increasing it in the second. The edge can be easily set above or below centre for occasions which demand such modification without the trouble and tentative trials necessary with the ordinary rest top.

The Best Tool Angle.—The ideal tool angle is that which will sever with the minimum of effort.

The best angle for a given material is one that wil endure a good bout of cutting without becoming dulled , a keener angle might go on for a short time, but before the end of the traverse was reached the edge would be blunted, and incapable of cutting cleanly or to size. The endurance of an edge is governed not merely by the angle of top rake or slope, but by the front or side clearance angle, since it is the compound of these two faces which constitutes the shape of the edge. In other words, a tool can be made of a keener cutting quality by increasing the clearance, or it may at the same time be weakened for effective duty by an excess of this clearance. Generally beginners tend to grind too much clearance. A very small degree of clearance will enable the cutting to proceed without friction at the front or the side, as the case may be.

If the tool point is raised above the centre, the actual value of the clearance will be reduced, and rubbing will commence at the nose A (Fig. 151), while if set below centre, as at B, the opposite tendency will arise. This important point has to be remembered when using an American type tool-post.

Height of Tool.—The question of the height of setting becomes affected by various conditions ; thus in taper turning the point should be exactly coincident with the height of centres, otherwise the taper will be wrong (this point is very fully discussed in the chapter on Taper Turning).

In screw cutting also the point ought to come level with the centres. But for other operations, presuming the clearance to be sufficient, advantage is often felt in placing the point slightly above the centre.

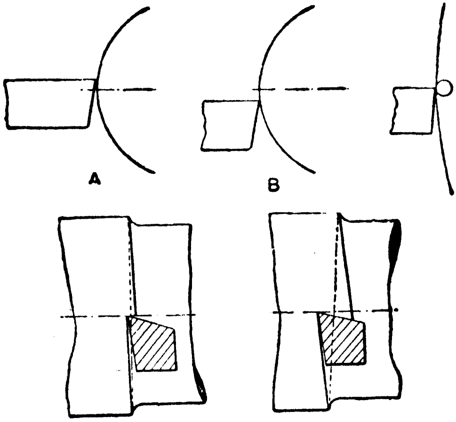


Fig. 151.—Effect of Tool Height on Front Clearance

Clearance is also affected by the work diameter, the chance of rubbing on a small rod being obviously much less.

Side clearance, required when a tool traverses laterally as on a shafting cut, is slightly affected by the rate of feed, but not to any vital extent. As the tool advances during the revolution it cuts a spiral formation, approximating more to the angle of clearance.

Too great a clearance angle weakens the point unnecessarily, and makes it liable to chip or snap off.

Top Rake.—The angle of top rake, which determines the relative keenness or thinness of the wedge that severs the metal, varies widely from zero down to as low as 35° with the horizontal. This extreme, taking the clearance at 7°, means a cutting angle of 48° (*see* the diagram A, Fig. 152). Such a keen angle is suited for turning soft steel and copper. Harder steels and the tough bronzes necessitate decreasing the rake, a good average being about 60° (*see* B), which is also suitable for cast iron.

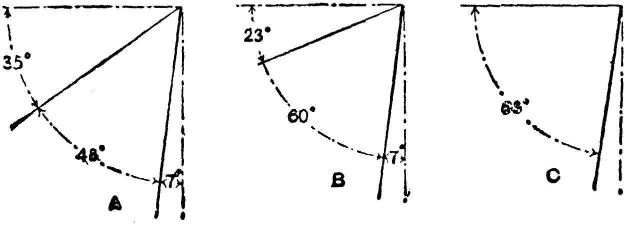


Fig 152.—Rake Effects

Brass, gunmetal, and chilled cast iron are dealt with satisfactorily without any top rake at all, the only departure from the full 90° consisting of the deduction due to the clearance. An exception, which needs pointing out, is when certain tools are fed straight in to a heavy duty; in these the level top C is adopted.

This applies also to parting tools and forming tools, which, from the severe pressure on their edges and the absence of relief afforded by the usual side traversing, are better made without top rake.

Cranked Tools.—In solid tools the familiar practice of cranking provides freedom, and enables repeated sharpening to be done without early necessity for reforging. This shape of tool is shown by A and B (Fig 153).

Side Rake.—Coming now to the question of side rake as it affects traverse cuts, such as those long shafts, etc., great favour is given to the simple class of tool ground to shape without forging, and having a sloped edge where it starts into the work. So instead of pointing an ordinary nose at an angle towards the direction of feed, rake is ground on this simple tool as in Fig. 154, whereby the slope falls directly away from the face being cut. Various roughing tools are shown by Figs. 154 to 156.

For working into corners it is necessary to select a narrow-pointed tool, with small radius of nose or diamond pointed as required. The diamond point is forged with the diamond part standing up on the same principle as shown at A in Fig. 157, and its axis is set straightforward, or to right and left, B and C. For brass and other materials which do not necessitate top rake, the same effect is procured by using a flat-topped tool pointed in, as in Fig. 158.

Tool-holders.—There are two methods of reducing the cost of tool steel for lathe outfits: one by employing tool-holders carrying removable cutters, the other by brazing on tips to shanks, the latter having a limited application by comparison with the former.

Tool-holder design possesses a main feature by which types are differentiated; that is, whether the cutter is presented in a manner that provides a fixed angle of clearance, or whether the top rake is fixed.

In the first type it is necessary to grind the cutter top to the desired rake A (Fig. 159), and in the second the front rake requires to be imparted, B. In the English type of slide-rest there is less space below the lathe centre than there is in the American tool-post arrangement, and this difference is reflected in the choice of tool-holders. The straight body (Fig. 160) throws the cutter point too high for an English rest, rendering a drop-head necessary (Fig. 161). A more handy type for the English rest is therefore one which has the cutter disposed with the axis approaching more to the vertical position. The Squire holder (Fig. 162) is a good example of the kind, being fitted with an adjusting scew for setting the cutter precisely to height.

Simple Holders.—A simple holder that the worker usually makes himself is minus the adjusting screw, the outline being as illustrated in Fig. 163, the split end clamping the cutter firmly on the tightening of the screw. Generally, it is the practice to make the holes square in holders of the patterns in Figs. 160 and 161, and those in Figs. 162 and 163 round; but occasionally the last named are square to receive cutters in imitation of the diamond-point tool.

The swivel bolt construction provides a very useful kind of holder, because the cutter can be slued round. Two designs are worth noting, the one carrying round

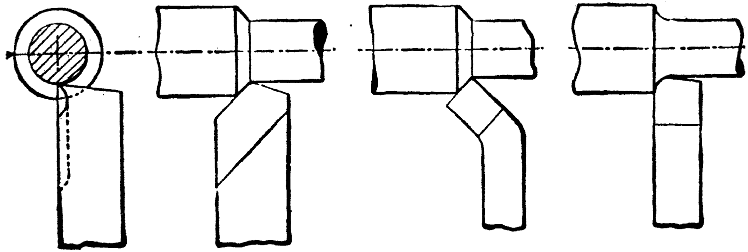
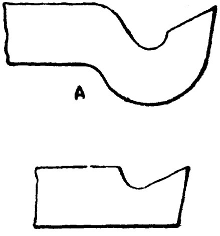


Fig. 154

Fig. 155

Fig. 156

Figs. 154 to 156.—Various Roughing Tools



B

Fig. 153.—Forms of Crank Tools

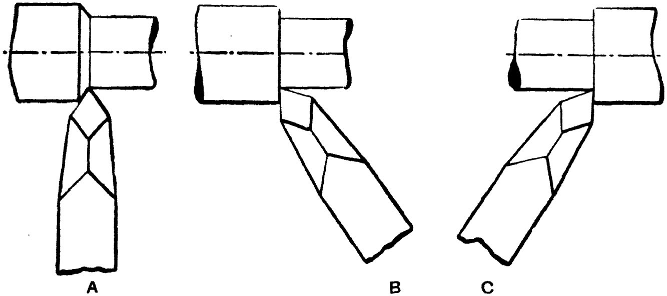


Fig. 157.—Applications of Diamond-point Tools

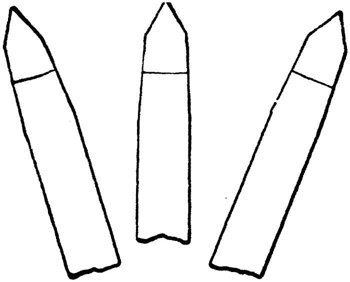


Fig. 158.—Position of Tools for Brasswork

or square steel in a head which is locked at the required angle by a nut (Fig. 164), and the other a section of steel which is deep and suited for heavy cutting (Fig. 165). The end of this is ground to the shape most suitable for the operation—either round-nosed, straight, bevelled, pointed, etc., a gauge giving a wide range of angles being furnished.

Boring-tool Holders.—Two systems of boring-tool holders are made; one consisting of a round bar with the end simply turned and ground to a suitable nose, the body being gripped in blocks or a split holder. The other system costs less for steel, because small bits or cutters are pinched in one bar, and renewals and breakages are made good at a trifling cost. The shapes of the ends of the solid tools are similar to those shown in Fig. 166, perspective views of a group being given in Fig. 167. For one size of bar a bored and split holder is clamped under the tool-plates or in the tool-post, the split being placed on one side to let the pressure bind the bar.

Bars with small inserted cutters are available in great variety. These the user can make for himself in most cases, though some of them are best purchased. Fig. 168 is a square-section bar, adopted for heavy duty. Making part of the length round (Fig. 169) enables the bar to enter small holes where the corners of the previous design would foul. In both specimens the cutter is shown set at right angles, which fact prevents it from going up into a corner. A bar with cutter hole inclined as in Fig. 170 is required for this opera-

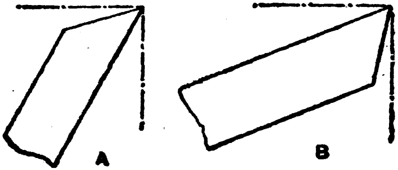


Fig. 159.—Principle of Tool-holder Cutters: A, Fixed Front Rake; B, Fixed Top Rake

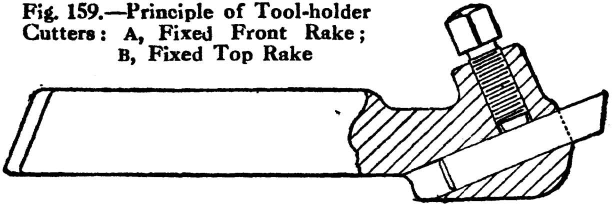


Fig. 161.—English Pattern Tool-holder

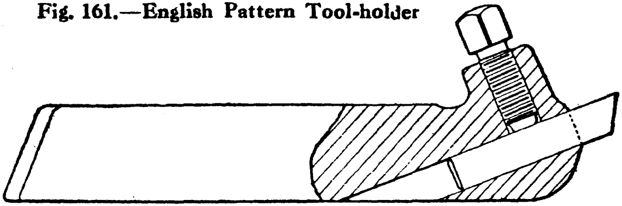


Fig. 160.—American Pattern Tool-holder

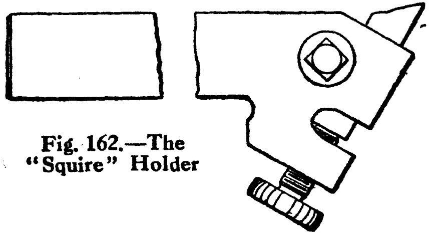


Fig. 162.—The "Squire" Holder

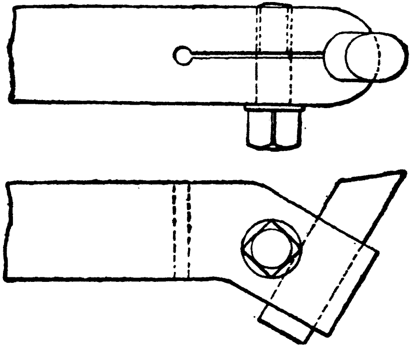


Fig. 163.—Simple Split Holder

tion, and in the case of square holders as Fig. 168 the other end of the bar may be used to take a hole angularly, enabling the one bar to serve the dual purpose. A modified holder has to be made for gripping roundbars in a slotted tool-post, the regular device being as shown in Fig. 171.

The Angles of Boring Cutters.—A reduction of top rake is preferable to prevent the digging-in that is likely to occur in going through rough-cast bores with lumpy surfaces. As scale and sand are plentiful in bores, the first cut should be deep, and made with a tool with a well-rounded edge, which will work more steadily and endure hard service better than a pointed nose. The top rake must be ground with due regard to the axis of the cutter in the bar.

Single-edged and Multiple Cutters. — A large amount of boring is performed with single-point cutters, notwithstanding the objection to the one-sided action, and for general work of a varying character the output is satisfactory. Bars with cutters or heads carrying two, three, four, or six edges are used more for repetition work, where one is likely to be able to make use of the sizes for a succession of jobs. It depends on whether the multiple-edge cutters are adjustable for size or not. A one-piece double-ended cutter is useful for either roughing or finishing, but does not retain its size for long in the case of the second-named operation The boring-heads provide means of adjustment for either two, three or more cutters. There is one detail in regard to the employment of two-edged

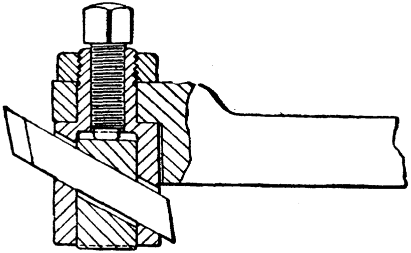


Fig. 164.—Swivel Holder

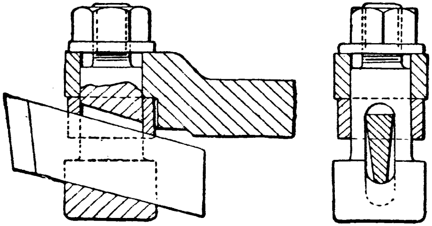


Fig. 165.—Smith and Coventry Holder

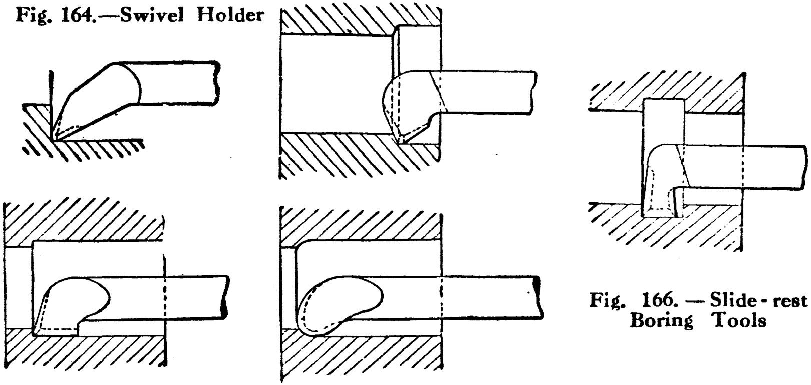


Fig. 166. — Slide-rest Boring Tools

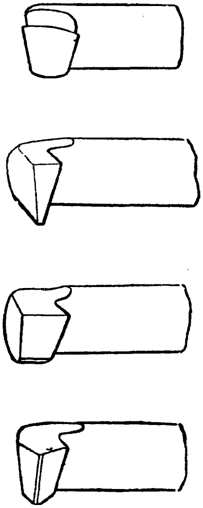


Fig. 167.—Perspective Views of Solid Boring Tools

cutters that is apt to be overlooked, and that is the effect of gaps in the circumference of the bore, caused by the casting of ports or other apertures. A single-point cutter travels round the circumference and is scarcely affected by the interval of non-cutting. But a double-ended cutter, or two cutters in a head are different in their operation; when one of them reaches the open space it becomes freed from the restraint of the metal, and allows the other end to recede to a certain extent.

The means by which cutters are held in bars depend on whether a screw or a wedge action is preferred, whether fine adjustment for diameter is wanted, and also if the bore is considerably larger than the bar. In the last-named event a cutter long enough to reach the bore would be springy.

The type most generally in use has a round-section cutter with the nose ground level, or with top rake. It is of rounded contour, or pointed or diamond shape, a set-screw placed on the front of the cutter bears upon a flat and gives a firm hold. Wedge fastening of round-section cutters is not a suitable way if the wedge is lined alongside the cutters, because it is necessary to make a large-sized flat on the cutter, and this weakens it. Choosing a square piece of steel for the cutter, however, gets rid of the objection.

A desirable position for the wedge is crosswise, where it exercises no disturbing influence. This method need not involve preparing a tapered hole, for the drive is easily obtained by using a parallel pin and filing a taper on its flank (*see* Fig. 172).

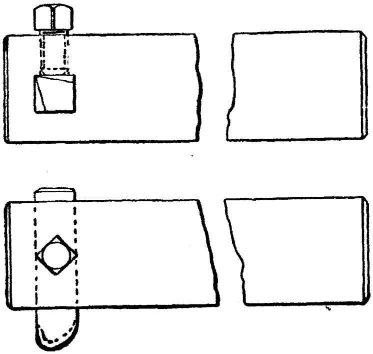


Fig. 168.—Square Boring Bar.

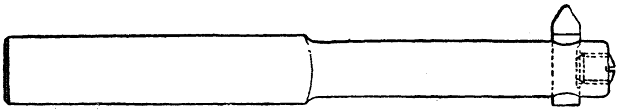


Fig. 169.—Part-round Boring Bar

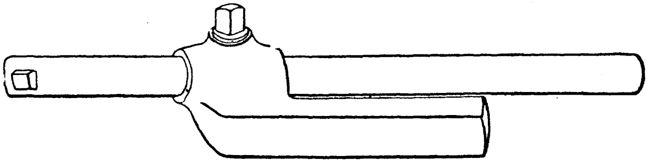


Fig. 171.—Holder for Gripping Round Boring-bar in Slotted Tool-post

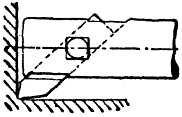
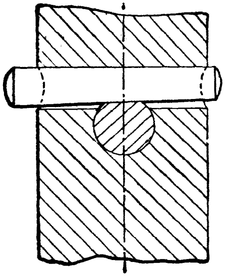
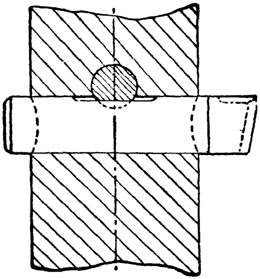


Fig. 170.—Boring-bar with Inclined Cutter-slot





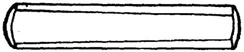


Fig. 172. — Cotter - pin Cutter Fastening

The round or square cutters offer a convenient alternative to the oblong cutters, and the holes in the bar for the former (especially the round) are easier to make than slots. The rectangular cutters are stiffer, however, and lend themselves to a greater variety of operations, because of their length.

Notched cutters, fastened by wedge and by threaded collar, are shown in Fig. 173; the collar has a gentle action without any necessity for hammering.

These cutters will keep their size for a good while if sharpened on the face, the consequent reduction in diameter being very slight. For working to limits, the results of sharpening can be neutralised by providing an adjustment with a screw, which means dividing the cutter in halves, the wedging arrangements being slightly altered to ensure a proper grip. Fig. 174 shows how this is carried out, the cutter edges have a slope to match the two inclines on the shim-piece *a*, which thus controls the expansion and draws the halves together when the cotter-pin is driven up. The variation in diameter comes about through screw *b*, pointed to force itself between the recesses at the inner edges of the cutters and so separate them.

Cutter Shapes for Various Operations.—Where the standard type of cutter passes through the work, there are other forms for specific purposes, a few of which may be examined now. Bell-mouthing, such as is done in steam cylinders, requires a bevel-edged cutter (A, Fig. 175), while "radiusing" is performed with edges shaped accordingly (B). The safest way

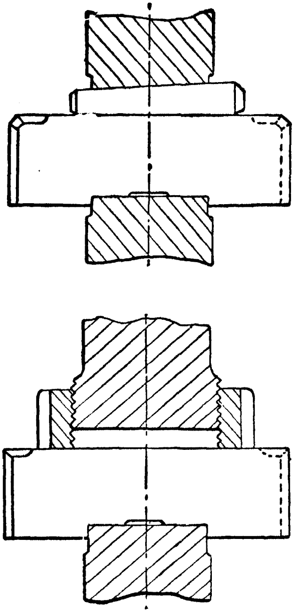


Fig. 173.—Notched Cutters Fastened by Wedge and by Threaded Collar

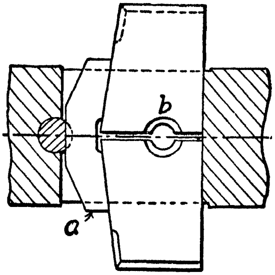
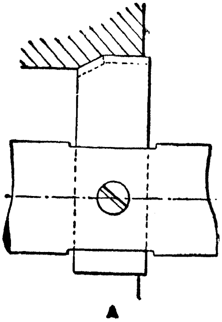


Fig. 174.—Cutter Adjustment to Compensate for Wear



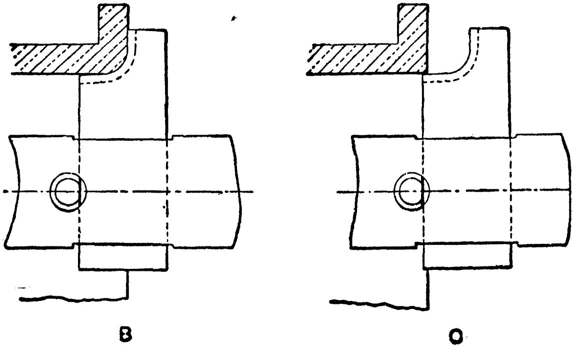


Fig. 175.—Miscellaneous Cutters.

of setting the cutter is shown at C, placing the entering edge just within the bore and then tightening up the wedge or other fastening. Facing is not a very simple process on the larger diameters, for there is difficulty in breaking under the scale with a broad cutter, and much care is required to make the cutter face quite square across. The safest plan lies in the adoption of the practice followed for preparing double-ended boring cutters, that of turning up in place; a double-sided facing cutter is best because it renders the facing easier. Breaking up the scale on the work assists the cutter to gain a bite into the metal, a rough file used cornerwise being applied to make a number of grooves on the scale.

Boring Heads.—The limitation to a simple cutter fixed in a bar comes when the size of the bore is too great in proportion to that of the bar, and the cutter overhang becomes excessive. Further, a head affords an opportunity to use three (or more) cutters for rough or finish boring or for reaming. More than three working edges are not usually wanted because these fulfil most ordinary requirements. A head lends itself well to the projection of special cutters from the periphery, the side, or the corner to carry on operations.

The plainest head is a disc fastened to the bar with set-screw or key, and receiving a round or square cutter, pinched with a side-screw.

When an end has to be worked up to, these heads are not suitable, because of the central attitude of the cutter. An awkward feature of any type of multiple-cutter head is the difficulty of securing a return to concentric accuracy after it has been taken off and replaced.

Knurling.—For knurling, a special apparatus is made called the Billing knurling tool. Figs. 176 and 177 illustrate the mechanism of the tool. Fig. 176 is a side view in part section at the cylindrical guide, to show more clearly the adjustment of wheels and arms, and method of fixing the right- and left-handed screw which actuates the arms carrying the knurling wheels (which are cut right- and left-hand, thus making the diamond pattern). The arms must be a neat fit in the cylindrical guide, and also a good fit at the screws which adjust the arms to suit various diameters. In Fig. 177 the apparatus is shown in plan and partial section. The carrier swivels in the shank (where it should be a good fit), so that it shall be self-centering as regards the height of the work.

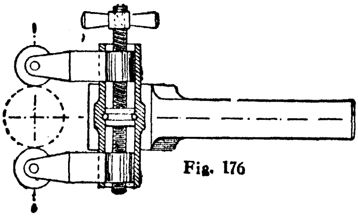


Fig. 176

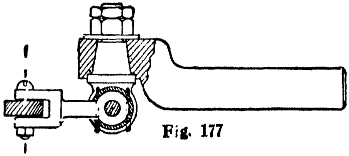


Fig. 177

Figs. 176 and 177.—Diamond-pattern Knurling Tool.

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